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## MISCELLANEOUS.

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## ERRATA.

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- Page 35, line 1, for "Weid." read "Wied."  
 „ 92, line 40, for "C. A. Rohwer" read "S. A. Rohwer"  
 „ 95, line 30, for "*tarchardiae*" read "*tachardiae*"  
 „ 137, last line, for "*cemara*" read "*camara*"  
 „ 219, line 10, for "G. M. Altson" read "A. M. Altson"  
 „ 281, last line, for "table I" read "table V"  
 „ 333, line 1, for "**sordia**" read "**sordida**"  
 „ 384, line 10, for "no. ii" read "no. 11"  
 „ 385, line 36, for "*Phenococcus*" read "*Phenacoccus*"



IMPERIAL BUREAU OF ENTOMOLOGY.

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## BIONOMICS OF THE TABANIDAE (DIPTERA) OF THE CANADIAN PRAIRIE.

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### I. INTRODUCTION.

Notwithstanding the undoubted economic importance of the TABANIDAE, which is second only to that of the CULICIDAE among blood-sucking insects, our information concerning the habits and life-histories of Canadian species is very meagre indeed. What knowledge we possess has been chiefly derived from the studies made by entomologists of the United States, who have discussed among others some of the species that occur on both sides of the international boundary. Of the species dealt with in the present paper, Hart (1896, p. 227) observed oviposition by *Chrysops*



*moerens*, Walk., in Illinois, and a description of the egg was given. This brief account was supplemented by Hine (1906, p. 36) in Ohio, who published a detailed description of the process of oviposition of the same species and was, moreover, successful in rearing *Tabanus lasiophthalmus*, Macq., from the egg to the adult—the first time that this had been accomplished for a Tabanid species. Jones & Bradley (1923, p. 310), working in Louisiana, discovered in the course of their investigations on the TABANIDAE a single larva of *T. reinwardtii*, Wied., from which an adult was reared, but no description of the larva was offered. Webb & Wells (1924) published an account of the partial life-cycle of *T. phaenops*, O.S., including descriptions of the early stages, as well as of *T. insuetus*, O.S., in which all stages other than the egg were obtained and described. With the exception of a brief description of the pupa of *T. epistates*, O.S., published by Malloch (1917), the author is not aware of any other work bearing specifically on the species that were encountered in the present investigation. Very little has been accomplished in Canada itself in enlarging our knowledge of the TABANIDAE, and what little has been done has been concerned with the recording and description of the adults. The author (1917) made a preliminary survey of the blood-sucking flies of Saskatchewan, but as his stay then was but a brief one of only two and a half months from the beginning of July to the middle of September, it was recognised that the list of species recorded was not by any means an exhaustive one. Of the TABANIDAE it was found that *C. moerens*, Walk., was the most abundant and widely distributed of the genus *Chrysops*, whilst another species, *C. fulvaster*, O.S., was collected in one locality only, a marshy ravine (Plate v, fig. 1) three miles north of the city of Saskatoon on the east bank of the South Saskatchewan River, into which a stream draining the marsh enters. Since 1922, when the present investigation began, all stages of these two species have been obtained, besides those of *C. mitis*, O.S., the adults having been reared from larvae collected in the field. In addition, *C. discalis*, Will., *C. excitans*, Walk., and *C. proclivis*, O.S., have been reared from their respective larvae, and *C. frigidus*, O.S., has been obtained from its pupa.

Of the genus *Haematopota* there would appear to be but one representative on the plains of western Canada, *H. americana*, O.S., which has been frequently reared from the larva by us and is apparently widely disseminated throughout both the prairie and the forested region to the north.

In point of species the genus *Tabanus* outnumbers both *Chrysops* and *Haematopota*. In the field we have collected *T. affinis*, Kr., *T. astutus*, O.S., *T. epistates*, O.S., *T. hirtulus*, Big., *T. illotus*, O.S., *T. insuetus*, O.S., *T. lasiophthalmus*, Macq., *T. metabolus*, McD., *T. nivosus*, O.S., *T. nudus*, McD., *T. phaenops*, O.S., *T. rhombicus*, O.S., and *T. septentrionalis*, Lw. Several of these have been reared in captivity from larvae and pupae collected in the field, whilst, in addition, both *T. duplex*, Walk., and *T. reinwardtii*, Wied., have been reared from larvae, although the adults have not so far been taken by us in nature. Similarly, *T. sonomensis*, O.S., was reared from a single larva, which was collected among a number of larvae of *T. septentrionalis*, but the adult, which is fairly common in British Columbia, has not been taken on the wing by us in Saskatchewan. As regards actual numbers *T. septentrionalis* is the most prevalent Tabanid on the prairie and may be said to be the most widely distributed of our northern species, extending into the forests of the north.

Previous to the settlement of Western Canada and its development as a rich agricultural area, the principal hosts of the TABANIDAE were the larger game mammals, which inhabited the plains and regions to the north, such as the American bison (*Bison americanus*), the moose (*Alces machlis*), the elk or wapiti (*Cervus canadensis*), the white-tailed deer (*Odocoileus virginianus*), the mule deer (*Odocoileus hemionus*) and the caribou (*Rangifer arcticus*), together with the horses of the native Indian population. The moose, deer and elk are still to be found in the northern regions, where the white settler has not penetrated, and these animals, together with the

barren-ground caribou, are there the chief native hosts of the TABANIDAE to-day. The moose, deer and elk are so pestered by horse-flies during the summer months that they frequently betake themselves to the protection of the water of the numerous lakes to escape annoyance. On the treeless tundra of the barren lands horseflies prove themselves to be a veritable plague, and the caribou, which band together in large herds and roam its vast extent, migrate southward in the summer towards the forests, where, in addition to finding an abundance of food, they escape to some extent their insect tormentors.

The breeding-grounds of the prairie TABANIDAE are to be found in the ponds or sloughs, which everywhere occupy the low-lying depressions. They vary in size from small pools of a few yards in diameter to large sheets of water several miles in length and breadth. Some of the smaller and more shallow sloughs may be only temporary, and are liable to dry up during periods of scorching drought in July and August. Occurring at low levels the water of these sloughs is drained from the surrounding higher ground in the spring, when the snow begins to melt, and their relative permanency is determined by the volume of the summer rains and intermittent periods of drought. The larger sheets of water, which might be designated as lakes, are usually permanent, but many of these disappear in the summer with prolonged drought, leaving large areas practically devoid of vegetation by reason of the thick encrustation of alkaline salts precipitated as the water evaporates. The comparative volume of the summer rains in any one year has thus a direct bearing on the numbers of TABANIDAE in the following year. Although we have found the eggs of only two species in nature, there is evidence that the greater majority of the prairie TABANIDAE deposit their eggs on the vegetation that overhangs the water of the sloughs. The rainfall of 1922 was a particularly light one, and during the egg-laying season (June to August) only 5.18 inches of rain were recorded. As a consequence, many sloughs in the vicinity of Saskatoon, from the margins of which larvae were obtained earlier in the season, dried up completely in July and August. When examined in 1923 these sloughs yielded no larvae, but in 1924, following the wet summer of 1923, when 13.78 inches of rain fell in the period June to August and the sloughs remained full, larvae were again obtained in fairly large numbers.

Throughout the prairie from November to March collection of larvae in the field is rendered impossible by the frozen nature of the soil. Records show that the temperature of the first six inches descends to  $-10^{\circ}$  F., and at depths of 3 inches temperatures of  $-20^{\circ}$  F. are not unusual. The frost penetrates to a depth of 6 feet. Hibernating Tabanid larvae are thus effectively imprisoned, and they remain torpid from the beginning of November until the warmth imparted by the melting snows thaws the ground in March and April and releases them to re-assume their development.

## II.—TOPOGRAPHY AND CLIMATE.

The prairie may be characterised as a vast, gently undulating, grassy plain of glacial drift standing at an average height of 1,800 feet above the sea, clothed with crisp nourishing grasses and supporting innumerable flowering plants. It constitutes by far the largest agricultural section of Canada, and wheat and oats are now being grown on a commercial scale as far north as latitude 56. This immense tract of fertile land, once supposed to be useless, is now a vast agricultural area of ever-increasing importance, as is indicated by the number and distribution of the railways. About 200,000 square miles in the southern part, in which the rainfall is light, are almost or completely treeless. Northward the precipitation increases, and evaporation being less, a good forest growth appears and persists almost to the Arctic coast.

Practically the whole plain slopes from the base of the Rocky Mountains eastward or north-eastward at about 5 feet to the mile to the edge of the Canadian (Precambrian) Shield, which is the ancient nucleus of the continent of North America. It

is drained by long rivers, such as the Saskatchewan River, that flow north-eastward either into Hudson Bay, or, by way of the Mackenzie River, to the Arctic Ocean.

The comparative aridity of the plains is indicated by the nature of the vegetation, some of which is distinctly xerophilous, such as *Elaeagnus commulata* (wolf-willow) and *Symphoricarpus occidentalis* (snowberry), shrubs which make low thicket-like growths of stunted plants. Trees are more or less conspicuous by their absence, save that the native poplar, *Populus tremuloides*, occurs in isolated groves or "bluffs," wherever soil-water is more abundant, a feature which is characteristic of semi-arid plains.

Throughout the prairie the climate is very uniform. The mean average winter temperatures of Alberta are higher than those of Saskatchewan or Manitoba, owing to the tempering influence of the warm south and south-west "chinook" winds, which sweep down from the mountains of British Columbia. Sometimes a change of wind from north and north-east to south-west will, in Alberta, mean a rise in temperature from perhaps 20° F. below zero to 40° F. above in a few hours. On occasions the effect of these winds may extend as far west as Regina and Saskatoon in Saskatchewan. It is largely owing to the "chinook" that the prairie of southern Alberta and part of south-western Saskatchewan are usually bare of snow during the greater part of the winter. During the winter months (November to March) temperatures of 30° F. below zero are often recorded, whilst in the summer temperatures of 90°-100° F. are not infrequent. The mean daily range of temperatures during the summer months is very large, amounting to 25° to 28° F. The mean total annual precipitation is from 15 to 18 inches, of which amount nearly 60 per cent. falls in the growing season, May-August. In 1923 at Saskatoon, with a total rainfall of 18.88 inches, 15.88 inches fell in the four months May to August. In the corresponding period in 1922 there were but 7.60 inches out of a total rainfall of 11.34 inches. A scanty rainfall is reflected in the diminished crop returns of that year and, as has been already indicated, materially reduces the numbers of TABANIDAE the following year. The snowfall is from 30 to 35 inches in the western and southern districts and from 10 to 15 inches greater in the east and north.

### III. EXTENT OF AREA INVESTIGATED.

When the investigation was commenced in the summer of 1922 our activities were confined to a radius of about 30 miles from Saskatoon, which was considerably increased in 1923 and 1924, extending as far as Prince Albert at the northern edge of the prairie, about 80 miles due north of Saskatoon, to Maple Creek in south-western Saskatchewan, about 175 miles from Saskatoon. Certain localities were selected within the area, where TABANIDAE were known to be abundant, and the marshes and sloughs were searched for the pre-imaginal stages. A single visit was made to Aweme in southern Manitoba in June 1925, and in this district, in the sloughs and sphagnum bogs ("muskegs"), there were found the larvae of *C. discalis* and *C. excitans* and pupae of *C. frigidus* and *T. lasiophthalmus*, besides the larvae of other species previously collected in Saskatchewan. *C. discalis*, *C. frigidus* and *T. lasiophthalmus* all occur in Saskatchewan, but we have not been successful in finding the early stages of these species in this Province, although the adults have been taken in various parts. With the exception of the Prince Albert region, which is forested, all of the localities in which material was collected were typical of the prairie.

### IV. HABITS OF THE ADULTS.

In western Canada species of the genus *Tabanus* are popularly called "bull-dog flies," a term which well expresses the pertinacity they display in attacking their hosts. Members of the genus *Chrysops* are known as "deer flies," although they



by no means strictly confine their attacks to deer alone. Tabanids attack both live-stock and human beings indiscriminately, inflicting on the latter painful bites, the effect of which may result in local oedemata. *H. americana*, the sole representative of the genus *Haematopota* on the prairie, is frequently observed around horses and cattle near its breeding-grounds and will readily attack human beings that happen to be in the near vicinity of these animals. As a rule, however, it is less frequently encountered than the species of the other two genera, and only on one occasion in our experience has it been observed in any great numbers attacking live-stock, when on a warm day in July 1927 numerous females were collected on horses at a farm near Dundurn, 30 miles south of Saskatoon. Every summer since then a few specimens have been captured in the field around cattle and horses or have been swept from the grass in the neighbourhood of sloughs.

On the wing *Haematopota* does not make its presence felt in the same degree as does *Chrysops* and *Tabanus*, in that it strikes an almost imperceptible note. Both *Chrysops* and *Tabanus* on the other hand produce an appreciably high-pitched note on the wing, which is of greater intensity in the latter, correlated with its greater activity and more powerful flight. The result is that both *Haematopota* and *Chrysops* are able to alight and begin biting without causing any great alarm to the human host, whereas the loud hum of *Tabanus* immediately warns one of its proximity and intentions. Cattle and horses grazing in the field suffer a great deal from the attentions of Tabanids during the months of June, July and August. Although they persist into September, their numbers have then become so reduced that they are a negligible factor so far as physical torment to the host is concerned. There can be no doubt as to the serious loss of blood incurred by live-stock in a season when Tabanids are abundant. It has been computed that a species such as *T. septentrionalis* will draw from its bovine or equine host about 0.2 cc. of blood in the time required to complete engorgement, which is about 10 minutes. For larger species, such as *T. affinis*, a relatively greater amount would be imbibed at each meal. Individual animals grazing in the open on a warm sunny day from 8 a.m. to 5 p.m., when the flies are active, stand to lose each one about 100 cc. of blood, if on an average 50 flies succeed in engorging themselves each hour. Such an estimate would be by no means an exaggeration of the situation at the height of the fly-season in July and August. Whilst the sapping of the vitality of the host is directly attributable to loss of blood, persistent attack by horseflies induces a restlessness that results in cessation of feeding. Therefore, during the fly season poverty of condition among live-stock is an indirect consequence of the activities of Tabanids. It must not be supposed that cattle and horses in good health submit passively to attack. Those parts of the body that can be reached by the switching of the tail are more or less protected, and the twitching of the skin due to the contraction of the cutaneous muscle will often, temporarily at least, disturb a Tabanid that has just alighted and is exploring the skin with its mouth-parts preparatory to making a puncture.

The author (1918) drew attention to the remarkable habit displayed by certain Tabanids of gathering around a stationary motor-car in the open. It has been our custom in collecting material to drive the car used in the present investigation as near to the sloughs examined as the nature of the surrounding soil would allow. It was then noted that on bright warm days in July and August, swarms of TABANIDAE, chiefly *T. septentrionalis*, would approach the car and, ignoring the presence of human beings or cattle close at hand, circle it in rapid flight, a few entering and coming to rest on the inside of the cover, which they tested with their mouth-parts as if biting. This phenomenon was never observed on dull days, and whilst it was suggested that the flies were seeking shade, it is more likely that the behaviour might be interpreted as a response to a thermotropic stimulus provided by the warmth that is radiated from the body of the car when exposed to the heat of the sun's rays. The same kind of behaviour has been noted in the case of *T. nudus*, *T. insuetus*,

*T. hirtulus* and, to a less extent, *C. moerens*. Many species, too, will keep pace in their flight with a car in motion, a fact which has been also noted by Jones & Bradley (1923, p. 311) in Louisiana. This habit was observed by us particularly in the case of *T. nudus*, *T. epistates*, *T. lasiophthalmus* and *T. septentrionalis*, whilst *T. reinwardtii*, which was known to be abundant in one locality, did not appear to be attracted to the car whether stationary or in motion.

On windy days TABANIDAE will frequently enter houses and stables, but in these circumstances they never attempt to bite the inmates. They usually congregate on the window-panes, and their only anxiety seems to consist in making their exit. Large numbers of *T. epistates*, *T. affinis* and *T. septentrionalis* were thus once observed in a settler's log-cabin on the shores of Cowan Lake, 80 miles north of Prince Albert. On another occasion the entrance-porch and kitchen of a farm-house 8 miles east of Saskatoon contained a swarm of *T. septentrionalis*, which had bred in a stagnant slough a few yards distant. In both instances under stress of a strong wind the flies had congregated on the outer walls on the wind side, which happened also to be the side where the entrances guarded by screened doors were placed. Every time the doors were opened some of the flies resting on the adjacent outer walls, as well as on the outside of the doors themselves, took the opportunity of entering and immediately flew to the windows. In the first place it is probable that the flies were attracted by the shelter offered by the houses, but it is also not unlikely that the warmth of the houses issuing through the screened doors into the cooler air outside also served as an attraction. Here, again, the reaction could, perhaps, in part at least be interpreted as thermotropic.

The males of TABANIDAE are only very occasionally encountered in nature. Those that were collected by us were taken by sweeping the herbage near sloughs in localities where horseflies were known to breed. In this way we have obtained the males of *C. fulvaster*, *C. mitis*, *C. moerens*, *T. illotus*, and *T. septentrionalis*. On 19th July 1922, two battered male specimens of *T. septentrionalis* were picked up on a gravel pathway near the University Buildings during a gale of wind. The males visit flowers, on the nectar of which they feed. Females have also occasionally been observed on flowers, and the presence of a coat of pollen on the bodies of a few specimens collected in the field is direct evidence of their flower-frequenting habit.

## V. TABANIDAE AND INFECTIOUS ANAEMIA OF HORSES.

Throughout the prairie there is prevalent among horses an obscure septicaemic disease of an epidemic nature, which is known as infectious anaemia or swamp fever. The latter name indicates that the disease is generally associated with low swampy pastures, and it is usually more prevalent during wet seasons than dry ones. Every year large numbers of animals succumb to its ravages. The progress of the disease is generally rapid in susceptible animals, but in some cases it appears to be less acute, and an apparently good recovery is made. It has been shown, however, that complete recovery rarely, if ever, occurs and that the apparently recovered cases act as latent carriers of the virus, a complication which has only recently been realised. When the disease has been present in a certain locality for several years, there are indications that the horses develop a tolerance to the virus, and the fatalities materially decrease. The disease is not by any means confined to Western Canada, but is widely distributed throughout the United States and occurs also in many European countries, South Africa and Japan. Although swamp fever has been investigated by a large number of veterinary scientists throughout the world, the causative organism has so far escaped detection by common cultural or staining methods. The general opinion now seems to be that it is a filterable, ultramicroscopic virus. Investigation has shown that it resists freezing, and is destroyed by exposure to heat for one hour at 60° C. and by exposure to direct sunlight. It has been found to be present in the blood and tissues of

infected animals at all times and also occurs in the urine, as well as in the secretions of the nose and eyes. It appears to be characteristic of the disease that it spreads slowly and tends to remain confined to individual farms or localities. Many theories have been advanced regarding its transmission in nature. Experiments have shown that food and drinking water contaminated with the urine of an infected animal may serve to convey the disease by ingestion. Scott (1922, p. 98) has argued, however, that the chances of this mode of infection occurring in open pastures are very rare, since an individual animal would not ordinarily obtain in its food or drinking water the amount of urine—in some cases several hundred cubic centimetres—which is required to reproduce the disease experimentally. Further, the virus is readily killed by the action of direct sunlight and would not persist very long in the pastures of Western Canada, which enjoy during the summer months several hours of bright sunlight almost every day.

After reviewing all the evidence submitted by previous authors, who have studied the disease, Scott (*loc. cit.*, p. 99) rejects the urine-contamination theory as a feasible method of transmission, because, among other considerations, it does not account satisfactorily for the seasonal incidence of the disease. Its onset occurs in Canada and the United States during July, August and September. This fact is significant when we consider that biting insects are most prevalent during these three months. Suggestions had frequently been made that swamp fever might be transmitted by some intermediate insect or Arachnid host. This hypothesis was first submitted to the test of experiment by Scott (1914, p. 180) in Wyoming, and he concluded that the stable-fly, *Stomoxys calcitrans*, could probably transmit the disease. Howard (1917) in Minnesota achieved the same result, but his experiments with *Tabanus illotus*, *T. lasiophthalmus*, *T. septentrionalis*, *T. affinis* and *T. zonalis*, proved abortive so far as transmission was concerned. Scott (1922) carried out a series of experiments at the Agricultural Experiment Station at Laramie, Wyoming, using mosquitos, *Stomoxys calcitrans* and *Tabanus septentrionalis*. The results with mosquitos all proved to be negative, but the disease was successfully transmitted by both the stable-fly and the Tabanid, which were fed on an infected animal and before the meal was completed were transferred to a healthy one, where the feeding was continued. As a result of his experiments Scott concluded that certain biting flies provide the most important means for the natural transmission of infectious anaemia of horses.

From a study of the habits of TABANIDAE in the field, we are convinced that they would constitute effective agents in the transmission of the disease. Breeding, as they do, in sloughs and marshes, they are found attacking horses under those very environmental circumstances that are closely identified with swamp fever. Their feeding behaviour, too, is such as to warrant the foundation of strong suspicions. They have frequently been observed to pass from one animal, on which they have commenced to feed, to another on which the meal has been completed. Since the inoculation of an infinitesimal amount of infective blood by means of a hypodermic needle is sufficient to establish infection in a healthy animal, it is not unlikely that the soiled stylets of the Tabanid mouth-parts can efficiently perform a similar function. Again, animals that have become emaciated by the disease are so lethargic that they prove easy victims for TABANIDAE, so that the chances of transmission are correspondingly increased. Further, the incidence of the Tabanids agrees more or less with that of the disease, so that the circumstantial evidence of field observations strongly supports that which has been obtained by experiment.

Whilst the theory of insect transmission seems to answer all of the criteria which both experiment and observation demand, there occurs to us one apparently serious objection, which the theory does not on first thoughts satisfactorily meet. Frequently on a single farm swamp fever may be rife, whilst on adjacent farms, which seemingly enjoy the same environmental conditions in all respects, the animals are found to be devoid of any symptoms of the disease and continue to maintain a healthy condition.



It might be supposed that horseflies, which are strong on the wing and are capable of undertaking long flights, would soon spread the disease from one farm to another, if they are the effective vectors that the theory supposes. That this rapid dissemination does not always occur demands explanation, which may be found in the fact that all horses are not equally susceptible to infection, and further that those animals that have been recently imported into a swamp-fever district are more liable to develop the disease than those which have inhabited it for some time. Indeed, there are indications, as Scott (*op. cit.*, p. 60) remarks, that the horses of a given locality grow tolerant to the virus after the disease has been prevalent for some years. It would thus be necessary to examine carefully the history of each animal before rejecting the theory of Tabanid transmission.

## VI. COLLECTING AND REARING.

Larvae were obtained by careful search in the mud around sloughs, along the banks of streams and in swamps. They were also sometimes found to occur under moss in these same situations. The method recommended by Marchand (1917) of isolating the larvae by washing the soil through a fine kitchen-sieve was soon discarded, because the time expended in treating even a moderate amount of soil was not warranted by the results. For turning over the soil the most effective implement proved to be a garden hand-fork, 34 cm. long, furnished with four prongs each 12 cm. long set vertically instead of horizontally. With the help of an assistant the author was successful in finding large series of most of the species hereinafter described with the exception of *C. frigidus*, *T. duplex*, *T. illotus* and *T. lasiophthalmus*. These were either not very abundant in the localities visited or, perhaps, our visits did not coincide with the time of greatest abundance of the larvae. An attempt was made to procure as many specimens as possible of a single species in order to minimise the risks of loss attendant on rearing, due to moulds and other untoward circumstances. Tabanid larvae are readily recognisable in the field and may be easily differentiated from other Dipterous larvae by their prominent downwardly projecting mandibles, the glossy sheen of the integument imparted by the minute longitudinal stria-like furrows of the chitinous cuticle, and the typical cylindrical or subcylindrical form of the body with its rings or projecting prolegs. The collector may fail to detect many of the immature larvae in the soil, but in the course of time the eye becomes so accustomed to their appearance that very few escape one's notice.

The number of specimens obtained in a given locality at a given time was found to depend on the species and its seasonal occurrence. Larvae were most abundant in the soil from May to June, but the larvae of some species may be found as late as October, disappearing only during those months when the adults are on the wing. After October field-collecting is rendered impossible by the extremely low temperatures which freeze the soil solidly. At any time during the period May to June as many as fifty specimens of *T. septentrionalis* could be quickly collected at certain sloughs, whilst only four or five specimens of the larvae of *T. nivosus* might be obtained after a whole day's search. The numbers of the larvae were found to be correlated with the relative abundance of the particular species in any one locality, and *T. nivosus* was by no means common anywhere on the wing as our records show. Large numbers of larvae would occasionally be found within the space of a few square feet, particularly so in the case of species of *Chrysops*, whilst on other occasions they would be sparsely represented over a fairly wide area all around the margin of a slough, throughout the extent of a marsh or along the banks of a stream. Their density would be determined by the comparative abundance of the egg-masses previously hatched in a given location, the extent of their migration subsequent on hatching and their food habits, whether saprophagous or cannibalistic as the case may be. In this respect it is interesting to note that species of *Chrysops*, which are probably rarely if ever cannibalistic or carnivorous, were generally found to be less widely disseminated



in the soil than species of *Tabanus*, which are usually more intolerant of their own kind and ferociously attack each other whenever the opportunity occurs.

The constitution of the Tabanid fauna of a particular pond or slough may remain fairly constant for several years, depending on the comparative stability of favourable environmental factors, or it may undergo changes, some species disappearing and others arriving in their stead. Tabanids desert a slough that has dried up during the previous year, and the presence of cattle that have access to a slough will often indirectly cause the same result. On warm summer days during the egg-laying season the cattle will enter and browse on the nutritious aquatic grasses and other plants, keeping them down to the water-level. They thus effectively eliminate those conditions, which are favourable to oviposition. At the same time we have found Tabanid larvae to be more plentiful in the sloughs of those districts, where cattle were numerous, since the opportunity for the adults to obtain a blood meal is thereby facilitated and breeding encouraged.

The method employed in rearing the larvae in the laboratory was similar to that recommended by Hine (1906, p. 20), who used half-pint jelly-glasses provided with perforated metal covers to ensure proper ventilation. Each vessel contained a certain quantity of clean moist sand covered over by a layer of algae, the whole serving as a nidus in which the larvae could burrow and obtain the food that was supplied in the form of small Crustaceans. Later authors have followed Hine's method, introducing slight modifications as individual circumstances seemed to demand. Where a large number of cannibalistic larvae have to be handled, necessitating the isolation of each specimen in a separate vessel, the size of the vessel and the space it occupies becomes an important consideration. For our purposes we found that wide-mouthed bottles of three-and-a-half-ounce capacity, 5.5 cm. in diameter and 8 cm. high, were sufficiently large. Each bottle was filled with moist friable garden loam to a depth of 2.5 to 3 cm., and Muscid larvae, Coleopterous pupae, pieces of earthworms, molluscs or ox meat were supplied as food. Least difficulty in rearing was experienced with those larvae that had almost reached maturity when collected. In many cases immature larvae would refuse food in the bottles, but were frequently tempted to feed openly in petri dishes. Larvae of certain species, the cannibalistic habits of which could be vouched for, would often display an attitude of perfect complacency towards each other, even when several were confined within the limited space of a petri dish; and this, too, after they had refused to feed for several days. This peculiar behaviour was noted in the case of *T. septentrionalis* on several occasions, but unfed larvae of *T. reinwardtii* proved pugnacious at all times. The larvae of *T. hirtulus* were found to be docile towards each other on all occasions, and consequently large numbers were confined together in the same breeding jar with no resultant loss from cannibalism. Not only did they ignore the presence of each other, but they invariably refused fresh animal food and appeared to subsist entirely on decaying organic material in the soil, which is even in the case of some admittedly carnivorous species a satisfactory alternative to the normal animal food-supply.

With the exception of the larvae of *C. proclivis* and *C. discalis*, which occasionally struck at each other with their mandibles when confined together in a petri dish, no other larvae of the genus *Chrysops* studied by us appeared to display any pugnacious tendencies. Even in the case of the two species mentioned the larvae were never observed to feed on each other. Numerous individuals of the same *Chrysops* species, including these two, were reared time and again together in the same receptacle with not a single loss. By actual test it was found that *Chrysops* larvae were never tempted by fresh animal tissues, even when starved, and there seems to be little doubt but that they derive their sustenance wholly from organic debris, actually devouring the soil for the sake of its humus content in a fashion similar to earthworms. All of the *Chrysops* larvae reared by us reached maturity without once having partaken

of fresh animal food. Anent these observations the following quotation from Stammer (1924, p. 126) is of interest: "Die Larven leben grosstenteils räuberisch von Schnecken, Würmern, kleinen Krebsen oder Insektenlarven. Auch die Artgenossen werden gerne angefallen. Für *Hexatoma*, *Tabanus* und *Haematopota* scheint das zuzutreffen. Besonders die grösseren Exemplare der *Tabanus*-larven erweisen sich als ungemein räuberisch. Jedoch schon Beling (1875) und Lécaillon (1906) weisen darauf hin, dass die in der Erde lebenden Larven von *Tabanus bromius* L. bzw. *Tabanus quatuornotatus* Meig. lange ohne tierische Nahrung leben können, wobei der Darminhalt eine völlig schwarze Farbe annimmt. Es wäre also nicht unwahrscheinlich, dass die Larven im Notfalle auch von faulenden organischen Substanzen leben könnten. Die Larve von *Chrysops coecutiens* ernährt sich sicher von solchen Substanzen." Again on page 125 Stammer says, "Ich züchtete die Tiere in kleinen Glasschalen oder Petrischalen, deren Boden mit Sand bedeckt wurde, und in die dann Moos oder das den natürlichen Bedingungen entsprechende Material kam. Gefüttert wurden die Tiere mit kleinen Krebsen, Käfer- oder Fliegenlarven, oder mit kleineren Würmern (*Tubifex*). Bei *Chrysops* ist eine Trennung der Larven nicht nötig, da sie sich gegenseitig unbehelligt lassen."

Although Marchand (1917) appears to have achieved a considerable degree of success in rearing Tabanid larvae in test-tubes containing a roll of moistened filter-paper, this method did not prove satisfactory in our experience after being submitted to a thorough trial. Large numbers of larvae, both recently emerged and more fully developed, succumbed by being drowned at the bottom of the test-tube in the half-inch of water introduced to keep the filter-paper moist, whilst others became fatally infected with the moulds that rapidly developed on the small pieces of meat furnished as food. It seems anomalous that Tabanid larvae, which are supposedly aquatic or, at least, semi-aquatic, should appear to be so readily drowned. We must remember, however, that whilst many larvae are admittedly aquatic, there are others, which, immediately upon hatching, sink to the mud at the bottom of the ponds, where they remain, deserting it only for the drier soil at the margins as they mature. Such species never actually live freely in water and have been observed to show their intolerance for an aquatic medium in rather a radical fashion. On several occasions it was found necessary to examine and draw live specimens of Tabanid larvae under the binocular microscope. In order to eliminate the interference of glistening effects caused by light reflected from the integument in a semi-dry condition the larvae were placed in petri dishes with water just sufficient to cover their bodies. The specimens were frequently left in the petri dishes overnight, when the examination had not been completed during the day. On the following morning it was often found that the larvae had almost completely eviscerated themselves *per anum*, particularly *T. septentrionalis*, *T. insuetus*, *T. reinwardtii*, *T. hirtulus* and *H. americana*. Although such larvae continued to live for some time after being replaced in moist soil, they were never successfully reared to the adult condition.

So far as the larvae of *Chrysops* are concerned, a soil medium rich in decaying organic material is necessary for their development as has previously been noted. Practically without exception the larvae of this genus, whether recently emerged or more mature, failed to thrive in the test-tubes, and they invariably died, unless they were transferred to a more suitable environment.

## VII. THE ORGAN OF GRABER IN THE LARVA.

In the anatomy of the larva the structure that is more characteristic than any other and, perhaps, unique in the Diptera is the pyriform, cystoid organ situated in the penultimate segment of the abdomen and visible dorsally through the integument of living specimens between the two tracheal trunks. It lies above the termination of the alimentary canal and is at times partly obscured by the lobes of the fat-body

surrounding it. Discovered by Graber (1878), who described its minute structure, the organ bears his name. The wider fundus of the cyst lies anteriorly and it gradually tapers behind to a slender, thread-like tube that opens dorsally in the furrow between the eighth and ninth abdominal segments. The whole organ is of a compound nature, consisting of a principal chitinous sac invested on its outer wall by an epithelium similar to that of the integument, from which it probably originates as an invagination. Enclosed within the chief sac there are smaller secondary capsules, also chitinous, which may be the remains of older, now functionless, sacs that persist after their function has been usurped by the new one that is formed at each moult. The various sacs may be entirely or partly separated from each other by transverse partitions. Generally from the anterior wall of each capsule there arises a pair of black, pedunculate, globular bodies that project obliquely backwards. A few may extend into the terminal filamentous tube, where they are usually unpaired, one behind the other. These bodies may be most satisfactorily interpreted as modified cuticular hairs.

The description of the organ published by Graber has been verified in its essentials by Henneguy (1904), Lécaillon (1905 and 1906) and Paoli (1907). There has, however, been some difference of opinion regarding its function. Graber, recognizing an apparent similarity between the organ and an otocyst, assigned to it an auditory function, in which case the pedunculate bodies would play the rôle of otoliths. According to Lécaillon the organ performed the function of a gland rather than a sense-organ. Paoli (1907) rejected both of these hypotheses in favour of one of sound-production, with which, however, Graber's organ has almost certainly nothing to do. The sharp clicking noise that the larger Tabanid larvae are frequently heard to make most likely arises from the striking together of the strongly chitinated mandibles and maxillae.

Besides the chitinous capsules and pedunculate bodies the organ is provided with a muscular mechanism, of which two bands, one on either side, diverge from the fundus anteriorly to their insertion laterally in the integument between the third and fourth abdominal segments. By the simultaneous contraction of these two bands the organ undergoes a forward displacement: by their alternate contraction the movement imparted resembles that of a pendulum, the lateral displacement being greatest anteriorly and diminishing posteriorly in the slender terminal tube, the extremity of which is attached to the integument. When the larva is at rest, the organ remains practically motionless save for occasional, very slightly perceptible oscillations. Immediately the larva moves, the oscillations assume a frequency that is almost constant whilst the motion continues. The action of the organ, with its otolith-like pigmented bodies suspended in the fluid of the capsules, is strongly suggestive of a static function, by which the maintenance of the equilibrium and the determination of the orientation of the organism might be achieved. Graber's organ would thus be strictly analogous to the more simple otocyst of the Hydro-medusae and the more complicated one of fishes. In the case of Graber's organ one might suppose the pedunculated bodies to play the rôle assumed by the sensory hairs of certain of the lining cells in the hydromedusan and vertebrate otocysts. Only the anterior pair, however, appears to be closely associated with the investing capsular epithelium at the fundus, where nerve-fibres described both by Graber (1879) and Paoli (1907) terminate. Stimulation of these bodies, incited by the movement of the fluid in the oscillating organ, might then be considered as being converted into nerve-impulses in certain cells of the capsule and transmitted thence by the associated nerves to the ganglia of the central nervous system. From these ganglia the impulses are conveyed to the muscles of the body by efferent nerves, causing them to contract. The co-ordination of these contractions determines the movement of the body as a whole in effecting both the equilibration and orientation of the organism. In the reasoning upon which the above deductions are made



there is recognised to be one serious weakness, which consists in the assignment of a hypothetical sensory function to the cells of the capsular epithelium. Should it be proved that they do not possess such a function, the organ probably could not be interpreted as static.

As regards the number of pedunculated bodies, there appears to be great variability, not only as between different species but even between different instars of the same species. Indeed, larvae of the same age belonging to the same species are frequently found to possess an unlike number. In some species the number of bodies increases with the age of the larva. Those that are present in the tubular part of the cyst are, according to Lécaillon (1905), in the process of being eliminated, but we have found no evidence in support of this view. In the case of mature larvae, we have found that the number of the pedunculated bodies and their arrangement are constant enough to warrant their use along with other characters in the identification of species. In certain of the plate-illustrations of the larvae we have represented the organ as apparent. In the mature larva of *C. mitis* (Pl. i, fig. 10) the pedunculated bodies are arranged in four pairs at the anterior end of the cyst, as they are in *C. moerens* (Pl. i, fig. 13), in which however there is one body less. In *T. nivosus* (Pl. ii, fig. 3) Graber's organ has two pairs of bodies, of which the members of the second pair are situated one behind the other at the commencement of the tubular prolongation of the cyst, an arrangement which corresponds to that of *T. reinwardtii*, in which the bodies are however relatively larger. *T. insuetus* (Pl. ii, fig. 10) has eight pairs, decreasing slightly in size posteriorly, but all confined to the anterior, enlarged portion of the cyst. *T. septentrionalis* (Pl. ii, fig. 12), on the other hand, has about fifteen bodies somewhat irregularly disposed, of which one or more may be present in the slender tube. *H. americana* (Pl. iii, fig. 7) has two pairs in the anterior enlargement and two or three arranged in linear fashion at the posterior extremity of the tube. *T. hirtulus* (Pl. ii, fig. 9) has a single pair of pigmented bodies near the fundus and a pair or three at the posterior extremity of the filament, with occasionally an isolated one between the two groups. The cyst is perceptibly narrowed just behind the anterior pair in this species, and the contents are brownish in colour.

#### VIII. NUMBER OF BROODS AND SEASONAL OCCURRENCES.

The probability is that, except under abnormal circumstances, the TABANIDAE of the prairie produce but one generation a year. It is almost certain that in the ordinary course of events none of them is double-brooded, but it may be that the life-history of some individuals may extend over a period of two years. Adults occur on the wing from June to September and are actively engaged in egg-laying during June, July and August. The great variation in the degree of maturity of larvae of the same species collected under similar conditions on the same date can only be explained by differences either in the rate of growth or in the time of hatching. Individuals that have emerged from the same batch of eggs do not all develop at a uniform rate, and as the egg-laying season of a species may extend over a period of about two months, there must necessarily be greater or less differences in the ages and dimensions of larvae that are hatched in any one year. These facts must be considered in any attempt to explain satisfactorily the finding of immature and fully-developed larvae, as well as pupae and adults, of the same species simultaneously during the summer. The persistence of some species late into September is accounted for on the same basis. Whilst the larvae of *Chrysops* were never encountered by us during July and August, they were found in September in the muddy margins of sloughs above the water-level. Larvae of *C. mitis* and *C. moerens* were collected at Saskatoon on 16th September 1924 and were found to be almost half-grown, measuring 12 mm. by 2 mm., the fully-developed larvae being 20 mm. by 3 mm. These specimens were kept in the laboratory throughout the winter in moist garden soil without any special attention being paid to them, save for the maintenance of the requisite moisture



in the breeding-jars, and in March 1925 adults emerged almost three months earlier than they customarily appear in the field. No food of any kind apart from the organic matter present in the soil was tendered them. The higher temperatures of the laboratory as compared with those outside would explain the marked hastening of development. In the field, where incubation occupies about one week and pupation about two to three weeks, *Chrysops* normally spends at least ten months as a larva, during which it hibernates in a half-grown condition. It is probable that, in its essentials, the life-history of *Tabanus* coincides closely with that of *Chrysops*, but so far, with the exception of *T. hirtulus*, we have not succeeded in finding in the field any larvae of *Tabanus* in August or September that could be undeniably associated with the brood that emerged from eggs laid earlier in the season. Possibly they may remain in the mud at the bottom of the sloughs throughout the winter following the season of their hatching and do not emerge until spring, to the drier conditions at the margins where they generally occur for the first time at the beginning of May.

The TABANIDAE that appear first on the wing are *T. illotus* and *T. lasiophthalmus*, which have been captured as early as the end of May and are prevalent throughout June, when *T. affinis*, *T. nudus* and *T. epistates* appear and extend their activities into July. At the beginning of July *T. septentrionalis* appears and rapidly outnumbers all other species, accompanied by *T. hirtulus* in lesser numbers but abundant in many localities, *T. insuetus*, *T. nivosus*, *T. reinwardtii*, *T. rhombicus*, *T. phaenops* and *T. astutus*, of which the last three are comparatively rare. Concerning *T. phaenops* and *T. duplex* little can be said, save that one male of each was reared in the laboratory in July 1923 and 1925 respectively from larvae collected in the field.

Species of *Chrysops* appear first in June and persist into July, after which only an occasional specimen of *C. moerens* was taken, the latest date of capture being 7th September 1923.

As regards *Haematopota*, larvae have been collected in every month from May to September, when other duties necessitated the termination of field work. The adults are on the wing in July. From the great variability in size of the larvae and their occurrence throughout the summer, it would almost seem as if *H. americana* has a life-history that extends over two years, or at least that some individuals may continue in the larval stage during two winters. That both *Tabanus* and *Haematopota* are capable of prolonging their life in the larval condition under unusual circumstances is amply testified by our laboratory records. Three immature larvae of *T. septentrionalis* and one *H. americana* collected in June 1923 have remained alive, but unchanged, in the laboratory up to the present date, 18th December 1925, a period of two and a half years. It will be noted that these individuals failed to pupate in July 1923 as one might have expected. Since they probably hatched from eggs laid in the summer of 1922, they are now at least three and a half years old. Six other larvae of *T. septentrionalis* and four of *H. americana*, which were collected in June and July 1923, died on 12th December of the same year. All the specimens were kept in soil in 3½ oz. bottles. Those that perished prematurely had become desiccated by the warmth of the laboratory owing to imperfectly-fitting corks. At intervals food was offered, chiefly earthworms and meat, but was almost invariably refused. Four larvae of *T. septentrionalis* collected in June 1924 and kept under similar conditions as the foregoing are also alive at this date, 18th December 1925. One larval specimen of *T. reinwardtii* collected on 11th June 1924 lived through the winter and died in May 1925 owing to an untoward accident. By reason of the tenacity exhibited by these specimens it may be concluded that Tabanid larvae are capable of accommodating themselves within limits to unfavourable conditions that inhibit their development, and of completing their development in the usual way when conditions become favourable again.

On 26th May 1925 three brownish-yellow larvae (Pl. ii, fig. 1) of *T. hirtulus* were collected in moist soil. They measured 22 to 25 mm. long and 3 to 3.5 mm. broad.

One specimen pupated on 28th May and on 22nd June there emerged a female imago. The two remaining specimens, together with others that were collected in the same situation during June, July, August and September, have remained unchanged in the larval stage. A few individuals were transferred to large flower-pots filled with soil and sunk in the ground on 1st September. When examined on 20th September it was found that they had deserted the surface and had descended to the bottom of the pots probably in preparation for hibernating.

Unlike the majority of *Tabanus* larvae, those of *T. hirtulus* have never exhibited the slightest evidence of cannibalistic behaviour. They have consistently refused the soft-bodied, aquatic Coleopterous pupae collected from the bank of the slough in which they were found, as well as other animal food that has been offered. In their feeding habits they appear to resemble the saprophagous larvae of *Chrysops*.

### IX. OVIPOSITION.

Of the various species studied only two were observed in the act of oviposition in the field, namely *Chrysops moerens* and *C. milis*. In an attempt to discover the egg-masses of other species the aquatic vegetation overhanging the water of sloughs, marshes and streams was thoroughly examined in a variety of different localities during the summers of 1923, 1924 and 1925. Floating debris and stones lying in the water were also closely inspected, but success did not attend our efforts. Time and again females of *T. septentrionalis* were observed to alight on the leaves of aquatic plants and assume a position as if preparatory to ovipositing, only to depart on the slightest alarm with the act unaccomplished. The difficulty of finding the eggs in nature has been experienced by other authors, although Hine (1903 and 1906) in the United States achieved a great measure of success in discovering those of eleven species, Patton & Cragg (1913) in India nine, King (1908, 1910, 1911) in Egypt four, and Neave (1915) in Nyasaland one. In discussing *T. sulcifrons*, Hine (1906) mentions his failure to find the eggs, and more recently Webb & Wells (1924), who investigated the TABANIDAE of the Antelope Valley in Nevada and California, refer to the difficulty which they experienced in finding the eggs of *T. phacnops*, a species which was very much more abundant than *T. punctifer*, the eggs of which were easily found. With *T. insuetus*, a species that occurs in western Canada, these same authors had no success. Lutz (1922), who has made extensive studies of the TABANIDAE of Brazil, argues that because he has not observed oviposition on plants, the eggs may possibly be laid on the ground or in other places where they are not very apparent. So far as the TABANIDAE of the prairie are concerned, this contingency appeals to us as being somewhat remote, especially as the larvae are always found in close association with an aquatic habitat and never in dry soil distant from water. In those species in which the egg-laying habits are known, the eggs are invariably laid so that the larvae immediately on hatching fall into the water, in which they may either remain or sink into the mud below. Oviposition in the soil, on the other hand, seems so contrary to the prevailing, almost semi-aquatic habits, that the co-existence of two such divergent modes of behaviour within the limits of a family, the habits of which are so uniform in other respects, is improbable. Further, the soil would appear to offer to the newly-hatched larvae a medium less suited to its delicate structure than water and mud.

The shy, elusive habits of many species, combined with the very extensive choice of suitable conditions for oviposition which the numerous sloughs and lakes present, are, in my opinion, the chief reason why the search for Tabanid eggs has proved practically fruitless on the prairie. The relative abundance of the adults in a particular locality does not necessarily mean that the eggs will be deposited near at hand, in that many species range far and wide and do not always remain in the immediate vicinity of their breeding-grounds. If, too, a blood-meal is essential to

the maturing of the eggs, it is possible that a large proportion of females may never have the opportunity to become engorged, since the live-stock population of the settled region of the prairie is sparsely distributed compared with the extent of the territory over which it is spread. Game animals, too, have been reduced to a minimum with the advance of settlement and cultivation.

The abundance of flies may not be strictly proportionate to the amount of egg-laying accomplished by any single species. One species, *C. fulvaster*, which appears to have a very localised distribution, presents a case in point. In one locality it was confined to a ravine (Pl. v, fig. 1) not more than half a mile long by a hundred yards wide, which was occasionally visited by a small herd of cattle. Only a very few adults were ever collected on the level prairie surrounding the ravine, and these were merely temporary followers of human beings or cattle on their way from the ravine to higher ground. On the floor of the ravine there was a swamp clothed in fairly dense vegetation and drained by a stream. In both the swamp and muddy banks of the stream, larvae and pupae were found. The conditions seemed to favour the discovery of oviposition in the swamp, but the result of repeated searches was negative. If only a limited number of females succeeded in maturing their eggs by reason of a restricted opportunity in obtaining a blood-meal, the circumstances in this particular case were comprehensible, since a few small egg-masses—two of which were laid by females in a glass vial in the laboratory—would be hard to find in the mat of vegetation in the swamp.

The elongated, flat, single-tiered egg-masses of *C. moerens* are deposited as a rule on the underside of the leaves of *Scolochloa*, *Scirpus*, *Carex*, *Sparganium*, *Typha*, *Persicaria* and *Chenopodium*, overhanging water. On bright warm days at the end of June and during July oviposition may occur at almost any hour of the day between 8 a.m. and 5 p.m., but is discontinued should the sky become overcast. The process has been accurately described by Hine (1906, pp. 36-38), whose account we have been able to verify in all its details. The female generally orients herself with the head directed towards the base of the leaf selected, but occasionally one may be observed with the head pointing towards the leaf-tip. On the linear leaves of *Scolochloa* the fly, instead of building up the mass on the two arms of a V, disposes the closely-arranged eggs in a single series of rows slanting slightly from the leaf margin to the midrib. Each row is laid down so as to overlap its predecessor, and thus only about one-third of the length of each egg in a row is exposed. When completed the mass possesses a strikingly compact appearance. Even after hatching has occurred, it remains firmly adherent to the leaf surface, to which it is attached by a gluey secretion that likewise coats the individual eggs and renders them water-proof. The insolubility of this material is shown by the fact that the eggs have hatched even when they have been kept immersed in 70% alcohol or 5% formalin.

The time occupied in the deposition of the individual eggs varies from 12 to 20 seconds. Each egg as it is laid is lightly brushed several times by the extremity of the ovipositor, as if it were being varnished. With each act of laying the extended ovipositor is recurved anteriorly beneath the abdomen, and not the thorax as stated by Hine (1906, p. 37), but is straightened out again previous to the next. Unless the fly be disturbed, oviposition continues for about an hour, during which time a mass of about 250 eggs will be laid. Frequently several masses may be deposited on a single leaf, some of which may be so close together as to impinge upon each other. In the laboratory *C. moerens* was readily induced to oviposit, and eggs were obtained from reared females that had not copulated, as well as from individuals captured in the field. The unfertilised eggs failed to hatch. On 7th July 1923 two females of *C. moerens* were captured in the field when attempting to bite. Each specimen was placed in a separate corked bottle at 12.30 p.m. At 1.40 p.m. one of the flies commenced to oviposit on the cork and continued the process for about forty-five minutes, when it ceased. In all about 200 eggs were laid, which hatched successfully.



On several occasions females were captured in the field in the act of oviposition and, together with the leaf on which the eggs were being laid, were carried in glass vials to the laboratory, where oviposition would proceed uninterruptedly until completed. The chorion of the egg is white when first laid, but with exposure to the sunlight it gradually darkens until it becomes a shiny, jet black. The darkening process occupies about six hours. Masses deposited in the laboratory and not exposed to direct sunlight darken very much more slowly.

Oviposition by *C. mitis* (Pl. i, fig. 7) is accomplished in a manner identical with that of *C. moerens*, only the shape and colour of the egg-mass, as well as the arrangement of the individual eggs, is somewhat different. Instead of the single tier there may be three or four, suggesting the egg-mass of a *Tabanus* rather than a *Chrysops*. Each individual mass is somewhat fan-shaped, more elevated in the middle than at the margins, narrow at the proximal end, where oviposition began, and broadening distally. An imperfect bilateral symmetry about the median longitudinal axis is recognisable in many masses, in that the individual rows of eggs instead of running at right angles to the axis are arranged each one in two parts like the two arms of a rather open V, the apex of which is directed distally. The apices of all the V-shaped rows lie on the axis. Some masses have a very irregular conformation, and their general disorderliness suggests the indefinite arrangement that characterises the egg-masses of certain STRATIOMYIIDAE, which oviposit on leaves. The overlapping of the rows is less than in the egg-masses of *C. moerens*, so that at least three-fourths of each egg in the superficial tier is exposed. Several masses may be placed so close together on a single leaf that the beginning of one and the end of another are not readily discernible. Often, too, one mass may partly overlap another. Like *C. moerens*, both reared individuals that had not copulated and females captured in the field oviposited freely on the walls of glass bottles, in which they were confined in the laboratory.

Two other species oviposited in the laboratory, *C. fulvaster* and *T. reinwardtii*. A female of the former was reared from a larva collected on 3rd June 1923. Pupation occurred on 20th June and the imago emerged on 6th July. This specimen was transferred to a glass-jar, and next day at 3 p.m. a mass of 113 eggs was observed attached to the wall. On 9th July the same individual laid a further batch of 90 eggs. Each mass consisted of but a single tier of eggs arranged in two sets of parallel rows, one on either side of the median line and slanting distally towards the middle from either lateral margin. This arrangement suggests, as was often observed in *C. moerens* and *C. mitis*, that the female in ovipositing had completed one row on one side before commencing on the corresponding row of the other and had thus alternated from side to side until the mass was completed.

The egg-mass of *T. reinwardtii* was deposited by a female on 15th July 1924. This specimen had been reared from the larva and oviposited on the walls of a glass vial in which it was confined. The mass, a small one of about 200 eggs, is brownish in colour. The eggs are arranged in four rows, and each row consists of several layers of eggs, three in the first, seven in the second, nine in the third and twelve in the fourth, so that the mass increases in thickness antero-posteriorly. The general shape is conical.

In order to obtain more natural conditions for oviposition than could be provided in glass receptacles, two cages were constructed after the pattern of those used so successfully by Patton & Cragg (1913, p. 303) in India and other authors. Each consisted of a basal tray of galvanised iron, 3 ft. by 2 ft. 4 in. by 6 in. To this tray there was fitted a non-detachable framework of strong iron rods  $\frac{1}{4}$  in. in diameter. Four of these rods were riveted to each of the four sides of the tray, set at equal distances apart and carried up to a height of 3 ft. 6 in. At this height they were bent and carried over the roof, where they intercrossed at right angles to each other. At the intercrossings the rods were soldered together so as to lend stability to the



whole structure. Over the framework there was closely fitted a cover of cotton netting, which allowed ready penetration of sunlight. Around its base the cover was equipped with a hem of stout cotton four inches deep, which overlapped the rim of the tray. To fasten the cover securely around the tray the hem was provided with a draw-tape, the free ends of which were tied tightly together. The cover was thus prevented from slipping free from the tray under the stress of the wind, when the cages were exposed outside. On one side of the cover a hole of seven inches diameter was cut, and into this a sleeve nine inches long was fitted. Flies were introduced into the cage through the opening of this sleeve, which was then securely tied with a piece of tape.

The tray was partly filled with mud procured from the margins of sloughs and planted with aquatic grasses and other plants that are found growing there. The mud was sloped off on one side and water added to a depth of about three inches partly immersing the slope, so that there was reproduced in miniature a section of the bank of a slough.

The species experimented with in these cages were *C. mitis*, *C. moerens*, *C. fulvaster*, *T. septentrionalis* and *T. reinwardtii*, of all of which a plentiful supply of adults was available reared from larvae and pupae collected in the field. A separate cage was kept for each species, and individuals of both sexes were introduced, but on no occasion was copulation observed. Food was furnished in the form of sugar solution, and the females continued alive for as long as three to four weeks. The males did not usually survive more than seven to ten days. *C. mitis* and *C. moerens* alone oviposited, one egg-mass of the former and two of the latter being obtained. These eggs failed to hatch. No success was achieved with females captured by sweeping among grasses around sloughs, nor with specimens taken whilst feeding on cattle and horses. On several occasions females of *Chrysops* that had been permitted to become engorged on a human host were introduced into the cages, but they died without ovipositing; one such individual survived for ten days.

As regards the duration of the period of incubation of Tabanid eggs, data were obtained from *C. mitis* and *C. moerens*. The minimum time in both cases was six days, but some masses required seven days. Hatching occurs very uniformly throughout an egg-mass and not longer than ten minutes separates the emergence of the first and last larva. When an egg-mass is ready to hatch, each egg is seen to split rather suddenly, and the transparent, white larva pushes itself out. It comes into contact with others similarly issuing and together they form an entangled, writhing group that soon falls from the egg-mass. Very soon after hatching the larva undergoes its first moult. Individual larvae of *C. moerens* that were observed to emerge at 11 a.m. on 27th July 1923 were kept in water in a Petri dish and were seen to moult for the first time at 4.30 p.m. on the same day.

#### X. EMERGENCE OF PUPA AND DURATION OF PUPAL PERIOD.

In the period intervening between the penultimate and last moults the Tabanid larva becomes quite sluggish and ceases feeding. Two minute, tubular spiracles make their appearance on the prothoracic segment near its base, one on either side, and project laterally and anteriorly. The larva may now be said to have assumed the pre-pupal condition, distinguished by its amphipneustic instead of metapneustic respiration and the partial retraction of the head within the prothorax. The pre-pupal phase persists for at least 24 hours, during which the external features of the pupa can be readily discerned as they develop within the translucent integument. When emergence is about to take place, the pupa pressing forward inside the larval skin causes a longitudinal split to appear antero-dorsally, and the head and thorax are liberated. By a series of alternate contractions and expansions of the abdomen, assisted by the leverage of the segmental fringes of retrorse bristles, the exuvium is

gradually withdrawn backwards until it reaches the terminal aster, to which it frequently adheres, the mouth-parts remaining intact and attached ventrally during the process. In cases where only a single larva of a species is being reared the retention and preservation of the final exuvium is desirable for use in describing the larva, bearing, as it does, unmodified the various characters of specific importance. The earlier larval moults are accomplished in a fashion identical to the last, with the exception that the function of the retrorse pupal bristles is performed by the abdominal prolegs.

For the successful emergence of the pupa it is necessary that the surrounding medium should be so compacted as to offer sufficient purchase for the proper action of the bristle-fringes and abdominal contractions. Otherwise the pupal skin, which is at first soft and pliable, may become indurated before release is completely secured, and the larval skin becomes so firmly adherent to the abdomen of the pupa as to constrict and malforn it. Such partly imprisoned pupae frequently occur in the laboratory, and very rarely do they produce adults.

Compared with the length of the larval stage the period of pupation is very brief and on the average does not generally extend beyond two weeks. In the laboratory, under a fairly uniform temperature of about 70° F., pupae of the same species proved to be very variable. In the case of *C. moerens* some individuals completed their pupation in six days, whilst others required as long as sixteen days, and adults would continue to emerge at any time between these two extremes. For most species the same degree of variability was experienced, indicating that factors other than temperature control the rate of metamorphosis. In the field the pupae are found in an erect position with the head uppermost embedded in the first inch of soil. During July, which represents the height of the emergence season, the surface of the soil may frequently become warmed to 90° F. Pupation may thus be accelerated to such an extent as to be completed in about five days.

## XI. DESCRIPTIONS OF SPECIES.

### **Chrysops discalis**, Will.

In the entomological collection of the University of Saskatchewan this species is represented by several females, which were all captured at Maple Creek in south-eastern Saskatchewan on 6th June 1907. In the same locality a few specimens were collected by the author on 8th June 1922. This species readily attacks human beings, horses and cattle, and the suspicion that it was concerned in the transmission of "deer-fly disease," or tularaemia, in Utah has been experimentally verified by Francis & Mayne (1922). As is the case with many species of *Chrysops*, the two sexes are strikingly different in coloration.

The *female* is light greyish with three longitudinal greenish-grey stripes traversing the dorsal surface of the thorax and four rows of black spots dorsally on the abdomen. In the *male* the thoracic stripes are black and wider than those of the female, whilst the black spots on each segment of the abdomen are coalescent. The dark shading of the wing of the male is much more intensified than in that of the female.

The larvae were discovered on 29th June 1925 amongst decaying vegetable matter washed up on the shore by the strongly alkaline waters of Baldur Lake in Southern Manitoba. From these a representative series of males and females were reared, emergence taking place during the second week of July.

The *larva* (Pl. i, fig. 1) is of a dirty white colour tinged with green from the vegetable contents of the alimentary canal. It measures 22 mm. long and 3 mm. broad. Greyish, pigmented annuli are faintly discernible at the anterior margin of all the thoracic and abdominal segments save the eighth abdominal. The striations of the integument are well defined on all segments except the first thoracic and anal, where they are extremely delicate and almost imperceptible under a high power of the

binocular microscope. On the dorsal surface of the anal segment (Pl. i, fig. 11) there are two pairs of small, linear pigment-markings and a faint, interrupted band of pigment where the segment is constricted posteriorly. The posterior, semilunar, tumescent lip of the anus is invested with a minute, dense, greyish-brown pubescence. The respiratory siphon is finely striated like the anal segment and bears a few slender colourless hairs near its extremity. Its shape is elongated conical.



Fig. 1. Pupal aster of *Chrysops discalis*, Will., ♀.

The *pupa* (Pl. iii, fig. 1) measures 13.5 mm. in length and 3 mm. in breadth at the thorax. Its colour is a tawny yellow. The rima of the prothoracic spiracle bears a slight hook posteriorly, which is absent in the male. The hooks of the aster (fig. 1) on the eighth abdominal segment, which is very similar in both sexes, are markedly acuminate. The lateral pair, which is directed upwards, is the largest, the dorsal the smallest. In the male the ventral comb of spines lying anterior to the anus consists of about sixteen points. In the female, as is the case in the pupae of all TABANIDAE, this comb is interrupted in the middle and is represented by a group of five or six spines on either side.

### ***Chrysops excitans*, Walk.**

In his Prodrôme, Osten Sacken (1875, p. 374) remarks that *C. excitans* is a common and widespread species occurring in New York and New Hampshire, Anticosti, Lake Superior, and on the Yukon and Mackenzie Rivers.

The black, shining facial and frontal callosities of the *female* are very prominent. The blackish thorax is closely invested with a tawny pilosity, which is especially thick on the pleurae. The sides of the first four abdominal segments are yellow, each one with a central black spot, which on segments two to four is excised posteriorly by a central triangle beset with golden hair, the triangle of the second segment being the most prominent. The body of the *male* is altogether black. The thorax is invested with black hairs mingled with yellowish grey ones, which are also present on the terminal segments of the abdomen. The male wing has an irregularly quadrate, hyaline spot in the centre enclosed on all sides by dark shading; in the female this is not enclosed below.

Adults were reared during the third and fourth weeks of June 1925 from larvae that were obtained on the shores of Douglas Lake in southern Manitoba on the 15th June.

The *larva* (Pl. i, fig. 2) is greenish grey, measuring, when full-grown, about 20 mm. long and 3 mm. broad. Its general appearance suggests the larva of *C. mitis*. The integument of all segments is fairly coarsely striated, with the exception of that of the first thoracic and terminal respiratory siphon, on which the furrows are shallower, less irregular and more closely set. The pubescence of the pigmented annuli, which are dark greyish-brown, is rather coarse. The colourless setae of the prolegs, as well as those in the intervals between the prolegs, are mostly tipped with black. The anal segment (Pl. i, fig. 3) is obconical and all of its pigmented areas

are invested with a coarse, dark-brown pubescence, including the projecting ellipsoidal margin of the anal region, the encircling band at the base of the respiratory siphon and the three pairs of dorso-lateral spots. The siphon is short and bears a projecting spine.

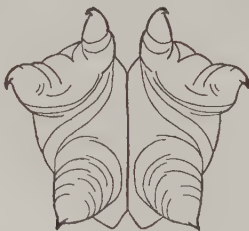


Fig. 2. Pupal aster of *Chrysops excitans*, Walk., ♀.

The *pupa* (Pl. iii, fig. 2) measures 13.6 mm. in length and 3 mm. in breadth at the thorax. Its colour is brownish yellow. The asters of the male and female (fig. 2) bear a close resemblance to each other, except that the dorsal hooks are more divergent in the male. The lateral are the most elongate, and the ventral the shortest but stouter than the dorsal. The extremities of all the hooks are recurved. The anal fringe of the male consists of about two dozen spines, that of the female being composed of two lateral groups of seven.

### ***Chrysops frigidus*, O.S.**

This species is comparatively rare. A single larva was obtained from Baldur Lake, southern Manitoba, on 13th June 1925, which pupated on 22nd June. Unfortunately this specimen died on 27th June. On 4th June 1925 a pupa was collected from the swamp at Onah in southern Manitoba, and from this a female emerged on 15th June. Adults were never encountered in the field, and from the remarks of Osten Sacken (1875, p. 385) on the distribution of the species, I am inclined to believe that it will be found more commonly in the wooded districts of the north than on the plains.

The *adult female* is comparatively small, measuring 7.8 mm. in length. The two basal abdominal segments are reddish yellow at the sides, and apart from a median greyish triangle on each segment except the first, the remainder of the abdomen is black. Anterior to the median triangle of the second segment there is a prominent, bilobed, black spot. The apical spot of the wing is coalescent with the cross-band, so that all of the marginal and first submarginal cells, as well as the anterior half of the second submarginal, are tinted with brown. According to Osten Sacken (*loc. cit.*) *C. frigidus* is the only one of all the *Chrysops* with an apical spot on the wings that is not marked with ferruginous in the middle of the face. The facial and frontal callosities are black and shining



Fig. 3. Pupal aster of *Chrysops frigidus*, O.S., ♀.

The *female pupa* is yellowish, 12 mm. long and 2.75 mm. in diameter. The aster (fig. 3) is comparatively broad, the lateral hooks with recurved tips being the largest,



and the members of the divergent dorsal pair the smallest. The interrupted pre-anal fringe consists of two groups of five to seven spines, which decrease in size medio-laterally in each group.

### ***Chrysops fulvaster*, O.S.**

This species was first described by Osten Sacken (1877, p. 221) from specimens collected in Colorado and Utah, where it appeared to be the common species. On the plains of western Canada it seems to be somewhat localised, being associated with swamps in ravines and with the banks of small, sluggish streams. Adults were reared in abundance from larvae and pupae collected near Saskatoon and Maple Creek in south-eastern Saskatchewan.

The *female* is brownish, about 6.7 mm. in length. The facial callosities are reddish brown, and that of the frons reddish black. The thorax is yellowish-brown pollinose, with three longitudinal, dark stripes. The dorsum of the abdomen is black, clothed with flavous hairs. The lateral margins of the first two segments together with the posterior margins of all the segments are yellow, and a yellow triangle occupies the middle of segments two to four. The infuscation of the wing has a sepia tint, except the apical spot, which is grey. Except the tarsi, which are black, the legs are mostly rufous, as likewise are the palpi.

The *male* is black. The thorax, which is clad with a mixture of black and yellow hairs, bears on either side above the pleura a yellow, pollinose stripe. The wing-shading is greyish black, and save a hyaline spot at the distal extremity of the basal cells and a hyaline crescent separating the cross-band from the apical spot, it practically covers the whole membrane.

The *larva* (Pl. i, fig. 4) measures 14.5 mm. in length and has a diameter of 2 mm. The colour is white with greyish-pigmented annuli, which however may be differently tinted according to the colour of adherent foreign particles. Some of the larvae examined had a distinctly ferruginous colour, derived from iron-stained particles deposited among the pubescence of the pigmented annuli and the setae of the prolegs, as well as in the microscopic longitudinal furrows of the integument. The anterior annulus of each thoracic segment occupies one-third of its length, and the first segment is entirely smooth. A smooth transverse crescentic band lies anterior to the dorsal tubercles of abdominal segments 2 to 7. The pigmented band of the anal segment occupies the posterior two-thirds and ventrally extends around and anterior to the anus. The respiratory siphon is finely striated and short, and possesses a terminal, projecting spine.

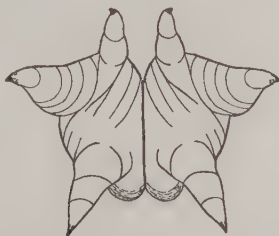


Fig. 4. Pupal aster of *Chrysops fulvaster*, O.S., ♀.

The *pupa* (Pl. iii, fig. 3) is pale yellow, 11.5 mm. in length and 2 mm. in diameter. The tubercle of the thoracic spiracle, with its dark brown rima, projects prominently. The hooks of the female aster (fig. 4) are more acuminate than those of the male, in which the dorsal and ventral pairs are more divergent. The dorsal pair of the

male are larger and the ventral pair smaller than the corresponding ones of the female. The pre-anal fringe of the male consists of 16-17 delicate spines; in the female there are two groups of 7 similar spines.

### ***Chrysops mitis*, O.S.**

Osten Sacken (1875, p. 375) recognised the resemblance between the *female* of this species and that of *C. excitans*, from which however it is easily distinguished by the altogether black colouring of the abdomen, clothed with greyish and not golden pubescence and the two grey stripes on the thorax, which are much more distinct than the corresponding yellowish lines in that species. Osten Sacken (*loc. cit.*) also noted that the pattern of the wing was similar to that of *C. excitans*, except that the brown colouring is not so dark and is more extended in the two basal cells, so that the hyaline space proximal to the cross-band is a little narrower, especially in the second cell.

The resemblance between the *males* of the two species is greater than that of the females. In both the body is entirely black. The thorax of *C. mitis* is clothed with hairs that are all black, whilst on the thorax of *C. excitans* there is a mixture of black and yellowish grey hairs. In *C. excitans* the extremity of the dorsum of the abdomen bears greyish golden hairs that form median triangles on the second, third and fourth segments. These triangles are absent in *C. mitis*, and there are only a very few grey hairs at the extremity of the abdomen. A subhyaline spot in the discal cell of *C. excitans* is smaller or entirely absent in *C. mitis*, in which the whole shading of the wing is darker verging on black.

The distribution of *C. mitis* on the prairie is fairly wide. It readily attacks human beings, horses and cattle. In Saskatchewan it has been found to occur at Saskatoon, Dundurn, Maple Creek, Leask and Prince Albert, at all of which places the eggs, larvae and pupae have been collected around sloughs.

The *egg* is elongate sub-cylindrical, tapering at both ends. The colour is greyish brown, and it measures 1.5 mm. long and 0.3 in diameter.

The *larva* (Pl. i, fig. 5), which is white with a tinge of green, measures 22 mm. in length and 3 mm. in diameter. The relationship that exists between *C. mitis* and *C. excitans*, as indicated in the resemblance of the adults, is likewise borne out in the larvae. The striations of the integument, the pigmented annuli of the thoracic and



Fig. 5. Pupal aster of *Chrysops mitis*, O.S., ♀.

abdominal segments and the black-tipped setae of the prolegs, are identical in both. The two species can, however, be readily separated on the characters of the anal segment. In *C. excitans* (Pl. i, fig. 3) the band at the base of the respiratory siphon stands isolated, whereas in *C. mitis* (Pl. i, fig. 10) it is connected with the pigmented area of the anal region, which extends for some distance dorsally. Again the three

pairs of dorso-lateral pigmented spots of *C. excitans* are represented in *C. mitis* by a single large mitten-shaped spot on either side of the anal segment, which, emerging from the furrow separating this segment from the preceding one (or 7th), may or may not be connected with the ventro-lateral pigmented area. In Graber's organ there are four pairs of pedunculated bodies.

The *pupa* (Pl. iii, fig. 4) is of a flavous colour and measures 16 mm. in length and 3 mm. in diameter. In the male the rima of the prothoracic spiracle is more abruptly bent posteriorly than that of the female. The tubercles of the aster (fig. 5) are very much alike in both sexes and differ from those of *C. excitans* in that they are not so sharply recurved at their apices. There are about two dozen spines in the pre-anal fringe of the male, in which isolated groups of two or three may be fused at their bases. In the female there are two groups of five spines.

### ***Chrysops moerens*, Walk.**

This species is the most abundant *Chrysops* of the north-west, extending not only throughout the plains but also in the forests north of the prairie. The *female* is vicious in its blood-sucking habits, attacking both human beings and live-stock indiscriminately. The character that serves to distinguish this sex from the females of other Canadian species of *Chrysops* is the prominent inverted V-shaped black mark on the dorsum of the second abdominal segment. The arms of the V are continued postero-laterally into two small black triangles that encroach on the pale greyish yellow of the sides. Between the arms of the V there is enclosed a greyish yellow triangle and similar median triangles are present on the following three segments. The abdomen of the *male* is almost entirely black. The large lateral greyish yellow areas of the two basal segments of the female are merely represented by a small diagonal yellow mark on either side of the second segment, which is confluent with the narrowed yellow margin. The median triangles are present, but smaller. Whereas in the female wing the two basal cells are devoid of shading, a dark brown infuscation extends almost to their distal extremities in the male. It also fills the anal cell and extends around the margin of the anal angle, which are both entirely hyaline in the female.

The *egg* is subcylindrical, tapering at both ends and shining black. It measures 1.6 mm. in length and 0.35 mm. in diameter.

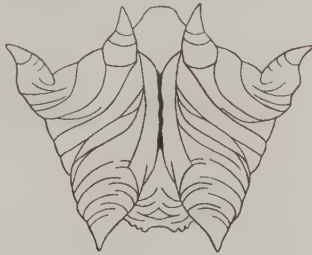


Fig. 6. Pupal aster of *Chrysops moerens*, Walk., ♀.

The *mature larva* (Pl. i, fig. 6) is pale flesh-colour and measures 21 mm. in length and 3 mm. in diameter. On account of their extremely fine pubescence the pigmented band at the base of the respiratory siphon (Pl. i, fig. 13) is more distinct and notable because of its breadth. Ventrally it is continued around the anal area to the anterior limit of the segment; dorsally it extends forwards at least half the length of the segment, and on either side of the median line its anterior margin here is prolonged into two slender arms that fail to reach the intersegmental furrow separating



the seventh and eight segments. The short respiratory siphon terminates in a brown exsertile spine, which can be extruded the length of the siphon itself.

The *pupa* (Pl. iii, fig. 5) is brownish yellow, measuring 14 mm. in length and 3 mm. in diameter. The tubercle of the prothoracic spiracle is transversely wrinkled, and its rima is slightly hooked anteriorly and posteriorly. The tubercles of the pupal aster (fig. 6) are larger in the female than in the male. The dorsal and ventral tubercles are sub-acuminate in the female and somewhat blunt in the male, whilst the lateral tubercles of the latter are more sharply pointed and more abruptly recurved than the corresponding ones of the female. In the male pre-anal fringe there are about a dozen spines, whereas in each of the two separate groups of this fringe in the female there are but five or six.

### ***Chrysops proclivis*, O.S.**

This species appears to be more abundant at the northern boundary of the prairie, where the plains pass into the forest. It was collected at Leask and Prince Albert and was found to be quite common in the coniferous woods of the north.

The colour scheme of the *female* is distinctive. The thorax is invested with a yellow pile and is traversed by a broad median longitudinal band of greyish green pollen, partly subdivided by a central black stripe. A similar but narrower band clad with a dense yellow pile runs dorsal to the pleura on each side, separated from the median band by a black stripe. The dorsal surface of the abdomen is yellow. In the centre of the basal segment there is a broad black subquadrate spot and an inverted V-shaped black spot in the middle of the second segment. The space between the arms of the V is occupied by a yellow triangle. The next three segments have each a transverse series of four black spots separated from each other by yellow, which occurs at the posterior margins of all the segments. The terminal segments are almost wholly black save for the yellow margins. The facial tubercles are black on the outside, and the interval between them is ferruginous.

The *male* closely resembles the female, only the thorax is darker and its investment of yellow pile is more dense. The two central black spots on abdominal segments 3 and 4 are coalescent basally, forming an inverted V like that in the middle of the second segment. On the fourth segment all the black spots have fused leaving the posterior margin yellow, which encroaches on the black mesially to form a small triangle. In the wing the dark brown of the basal cells, which is confined to their

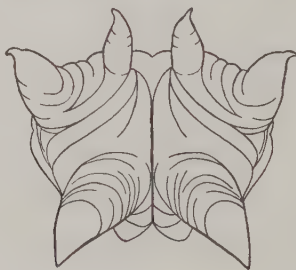


Fig. 7. Pupal aster of *Chrysops proclivis*, O.S., ♀.

proximal ends in the female, extends almost to their distal extremities in the male, and in the latter is connected to the cross-band along the proximal end of the fifth posterior cell. The anal cell, hyaline in the female, is distinctly infuscated in the male. A central sub-hyaline spot present in the discal cell of the male is absent in the female.

The *mature larva* (Pl. iii, fig. 6) is pale flesh-colour, but some that were examined were brownish white and others had a decided greenish tinge. It measures 20 mm. in length and 3 mm. in diameter. The striations of the first thoracic segment are only faintly discernible, and they are also very delicate on the respiratory siphon. The pubescence of the annuli is pale greyish-brown, rather faint on the thoracic and anterior abdominal segments but increasing in distinctness and coarseness on the posterior segments. The anal or eighth segment of the abdomen (Pl. i, fig. 12) is rather abruptly attenuated in its distal half, which is tubular in shape, and the respiratory siphon is elongated, with no exsertile spine. At the constriction of the segment there is a well-marked encircling band of pigment, the anterior margin of which is irregular. It is continued to the base of the siphon but decreases in intensity posteriorly. Ventrally the band may or may not be continuous with the anal pigmented area, from which there extends on either side a dorso-lateral extension traversed by a sharp deep groove. Dorsally on either side of the median line there are three linear spots. In its form, colour and pigmentation the larva suggests that of *C. discalis*.

The *pupa* (Pl. iii, fig. 8), which is brownish yellow, measures 12.5 mm. long and 3 mm. in diameter. The lateral tubercles of the aster (fig. 7), which are directed outwards and upwards with apices recurved, are the largest. The ventral tubercles of the male are relatively smaller than the corresponding ones of the female, in which all the tubercles are more sharply pointed. The pre-anal comb of the male has a variable number of spines, sixteen to twenty-four; in the female there are merely five or six in either group, but some of these with bicuspid or tricuspid extremities represent a fusion of two or more simple spines.

### ***Haematopota americana*, O.S.**

This greyish black species is widely distributed throughout the prairie and is apparently the only one of the genus represented in western Canada. The females have been found to bite human beings, horses and cattle, and have frequently been captured on a warm sunny day resting on the walls of stables. Adults of both sexes have been reared from larvae obtained from the banks of sloughs.

In the *female* the first segment of the antennae is very much thickened, but less so than that of the male, in which the second and third segments are relatively smaller. The face is speckled black and white and invested with a thick pile of white hairs, which is denser and mixed with black hairs in the *male*. The frontal callus, which is shining black, extends the breadth of the frons, and dorsal to the callus are two velvety black spots. The greyish black thorax is traversed by three median white lines that extend to one-third of its length, and at the centre there occur two white dots, one on either side. In the male these lines are abbreviated and less distinct, and the dots are less prominent. Each segment of the female abdomen beginning with the third bears a pair of white dots, and the posterior margins of the segments are outlined in white. In the male the dots are less prominent and begin on the fifth segment. The wing picture is identical in both sexes, consisting of a lace-like pattern of grey and white, the only difference being that the grey is more intensified in the male.

According to Osten Sacken (1875, p. 396) the species bears a marked resemblance to *H. pluvialis* of Europe, the two apparently differing in a few minor characters of the antennae, such as the relative thickness of the basal joint and the colour at the base of the third.

The *mature larva* (Pl. iii, fig. 7) is white, sub-cylindrical and measures 21 mm. in length and 3 mm. in breadth. The head-capsule is slightly ferruginous, with a dense tuft of reddish bristles on either side at the base of the labrum above the antennae. The mandibles are blackish brown. The first thoracic segment is attenuated anteriorly,

where it is surrounded by a wide collar of yellowish pigment, continued backwards in four stripes along the paired dorso-lateral and ventro-lateral furrows that divide this and the remaining body segments, except the anal, into dorsal and ventral and lateral areas. The dorsal and ventral areas of the thoracic segments are almost smooth, but the lateral are distinctly striated. The pigmented annuli of the second and third thoracic segments are comparatively narrow and very faint, as is the case also in the abdominal segments, in which the striae are more widely separate on the dorsal and ventral surfaces but more pronounced and closely aggregated on the lateral areas. The space intervening between the prolegs and the annuli of abdominal segments 2 to 7 is impressed with very minute longitudinal striae. At the base of the short conical respiratory siphon there is a narrow band of yellowish pigment similar to that which invests the projecting anal prominences. Some immature larvae that had been killed and preserved in 5% formalin were found to be devoid of the integumentary striae and to be quite smooth.



Fig. 8. Pupal aster of *Haematopota americana*, O.S., ♀.

The *pupa* (Pl. ii, fig. 8) is yellowish brown and measures 12.75 mm. in length and 3 mm. in width. The two truncate, conical tubercles dorsal to the bases of the antennae bear each a single bristle, where the corresponding tubercles of *Chrysops* are each provided with two. The tubercle of the paired thoracic spiracles are somewhat inconspicuous. Each segment of the abdomen, except the first and last, is encircled on its posterior third by a single row of backwardly-apressed bristles increasing in size up to the seventh. On any one segment they are longer on the dorsal than on the lateral and ventral areas. The lateral tubercles of the aster (fig. 8) are the largest, the dorsal the smallest. A dorso-lateral comb is present bearing about six spines that are longer and more robust in the female than they are in the male.

### ***Tabanus duplex*, Walk.**

Osten Sacken (1875, p. 474) included this species in a list of TABANIDAE described from North America that remain unknown, unrecognised or doubtful. On the occasion of a recent visit to the Natural History Museum in London, Prof. J. S. Hine had the opportunity of examining Walker's type specimen and pronounced the single male that I had reared to belong to this species. Two specimens of the full-grown larva were collected from the bank of a pond near the University at Saskatoon. Unfortunately they pupated before it was found convenient to submit them to careful examination, and a detailed description of the larva is thus not possible. All that can be stated is that the *larva* was white in colour and sub-cylindrical in form, bearing a superficial resemblance to the larva of *Haematopota americana*, with which at the first casual inspection it was erroneously associated. Both pupae happened to be males, and an adult was reared from one, the other being preserved for the purpose of description.

The *male* measures 12 mm. in length. The whole insect is greyish black save the reddish orange sides of the first four abdominal segments. Covering both the



thorax and abdomen there is a dense vestiture of silvery white hairs, elongated on the thorax and with a few interspersed black hairs on both thorax and abdomen. The reddish brown eyes have a yellowish pilosity, and each is traversed during life by a narrow dark purple stripe at the boundary between the two contiguous groups of large and small facets. The ocelligerous tubercle is prominent. The antennae are reddish yellow, the basal segment being paler and clothed with elongated black hairs; the annulated portion of the narrow third segment has but two joints, the distal extremity of the second being tipped with black; the excision is comparatively shallow, so that the upper angle, bearing a small tuft of black hairs, projects but slightly. The palpi are white, beset with black hairs. The ground-colour of the thorax is black, the ante-alar tubercle being white. The legs are reddish yellow and beset with black hairs; the coxae, proximal ends of the femora, distal half of the fore tibiae, the fore tarsi and all (save the basal joint) of the middle and hind tarsi are black. The wings are hyaline, with veins mostly black; the first posterior cell is broadly open.



Fig. 9. Pupal aster of *Tabanus duplex*, Wied., ♂.

The *male pupa* (Pl. iv, fig. 6) measures 12.5 mm. in length and 3 mm. in diameter. The head and thorax are ferruginous, the abdomen yellowish white. The rugose frontal and piliferous tubercles of the head are but slightly elevated. The anterior margin of the inconspicuous flattened tubercle of the thoracic spiracle is fluted, and the arciform rima inserted more laterally than apically. Each of the abdominal segments 2 to 7 bears a double row of yellowish bristles, especially elongate on segments five to seven. The bristles of the anterior row tend to project straight outwards, those of the posterior row are backwardly appressed. In the terminal aster (fig. 9) the ventral tubercles are the smallest and project straight back. The lateral tubercles, which are the largest, are broad at their bases, deeply rugose, abruptly constricted at their middle and thence taper gradually to their pointed extremities. They extend almost straight laterally with a slight dorsal inclination. The apices of the dorsal tubercles are slightly recurved laterally. The dorso-lateral comb consists of a low prominence bearing four or five aborted denticles and is quite similar to the lateral comb. In the pre-anal fringe there are about two dozen strongly chitinised bristles.

#### ***Tabanus hirtulus*, Big.**

This species is quite common throughout the prairie, and the *female* has been frequently taken whilst biting horses and cattle. In this sex the two basal segments of the antennae and the base of the third segment are reddish, the remainder black. The palps are yellowish white, clothed with a mixture of white and black hairs. The white face is invested with long dense white hairs, as are the pleurae and sternum of the thorax. The frontal callus is black with a brownish centre and connected above to a small black spot. The ocelligerous tubercle is ferruginous. The eyes are pubescent. The dorsum of the thorax is black and traversed by five narrow grey lines bearing flavous hairs. The ante-alar tubercle is reddish and clothed with black hairs. The abdomen is black and on each one of the segments 2 to 6 there are three greyish white triangles, a median and two lateral. On segments two to four

the lateral regions are frequently reddish. The legs are black, except the red distal extremities of the femora and the greater part of all the tibiae. The wing is hyaline, frequently with a slight infuscation, and the veins are black. A short spur arises from the proximal end of the anterior branch of the third vein.

A single female was reared from a pupa, and it is surmised that another pupa that died is the male of this species.

The *full-grown larva* (Pl. ii, fig. 1) is brownish yellow, coriaceous, and measures 27 mm. long and 4 mm. wide. The head-capsule is ferruginous, the mandibles shining black, and the anterior dorso-lateral hair-tufts are red. Each of the segments of the thorax is encircled at its anterior margin by a pigmented band, reddish yellow and fairly broad on the prothorax, pale yellow and narrow on the second and third segments. Lateral stripes are but faintly indicated, a pair on either side of the prothorax and two similar but imperfect pairs on either side of the meso- and meta-thorax. A faint greyish brown annulus surrounds the anterior margin of abdominal segments 1 to 7 and the posterior of segment 7. The anal segment (Pl. ii, fig. 9) gradually narrows to the slightly protruding respiratory siphon, the base of which is surrounded by a band of brown pigment and is connected with the pigmented pubescence of the anal area by an ill-defined L-shaped mark. The setae of the rather inconspicuous prolegs form a colourless to pale yellow pubescence. With the exception of the dorsal and ventral areas of the thoracic segments, which are comparatively smooth, the remainder of the integument is striated throughout. In Graber's organ the normal number of pedunculated bodies is two pairs, one anteriorly and one posteriorly. In one specimen 15 bodies were counted in an enlarged brownish sac with a pair of accessory detached bodies on the left side, apparently independent of the main organ.

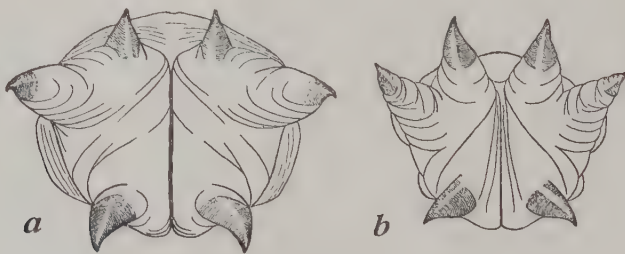


Fig. 10. Pupal asters of *Tabanus hirtulus*, Big.: a, ♀; b, ♂.

The *pupa* (Pl. iv, fig. 2) is brownish yellow, with the thorax darker than the abdomen. It measures 19.5 mm. long and 3.5 mm. wide. The tubercle of the thoracic spiracle is but slightly elevated, and its rima suggests the shape of a question mark. On the posterior third of abdominal segments 2 to 7 there is an encircling double row of backwardly appressed spines, of which some of the anterior series are quite short. In the female aster (fig. 10, a) the lateral tubercles are the largest and directed outwards and backwards. The dorsal and ventral tubercles are subequal and widely divergent. In the male (fig. 10, b) the tubercles of the dorsal and lateral pairs are of equal size and on either side closely co-adapted at their bases. The small ventral tubercles are more widely separate than the dorsal.

### ***Tabanus illotus*, O.S.**

This species is common throughout the plains of Saskatchewan, Manitoba and Alberta. It bears a strong resemblance to *T. metabolus*, McD., which is however more abundant in wooded areas, whilst *T. illotus* is more frequently associated with

open country, although it extends into forested regions, where it is found along with *T. metabolus*. The latter was considered by Osten Sacken (1875, p. 469) as being merely a variety of *T. illotus*, a view to which the identity of the seasonal appearance of the adults might have lent support. Both are found on the wing as early as the last week in May and, together with *T. affinis*, *T. epistates*, *T. lasiophthalmus* and *T. nudus*, represent the advance guard of the Tabanids of the prairie.

*T. illotus* and *T. metabolus* can be readily distinguished on the basis of the characters of the palps, face, subcallus, the markings of the abdomen and the wings. So marked are those differences that Osten Sacken (*loc. cit.*) at the termination of his description of *T. illotus* suggested the possibility of the two "varieties" having distinct specific rank. It remained for McDunnough (1922, p. 238) to establish the separate identity of *T. metabolus*.

In *T. illotus* the palpi are pale yellowish and clothed with appressed white hairs, among which there occur a very few black ones. The subcallus is dusted with greyish white pollen, and above it the quadrate, black callosity is continued dorsally into a narrow prolongation. The face and cheeks, as likewise the pleurae and sterna of the thorax, are greyish-pollinose with white hairs. On the dorsum of the second and third abdominal segments there are two oblique, whitish, lateral spots sometimes underlain with reddish, and on the following segments corresponding smaller spots are faintly discernible. The wings are subhyaline, with faint brownish clouds on the cross-veins and bifurcation of the third vein. In *T. metabolus* the palpi are much darker, because of the greater abundance of black hairs on their distal halves. The subcallus is denuded, brownish black, and the linear prolongation of the frontal callosity expands into a broad arrowhead-like spot. The face and cheeks are yellowish-pollinose beset with yellowish hairs, as are the sterna and pleurae of the thorax. The oblique, whitish abdominal spots are more prominent and the underlying reddish tint more conspicuous. The infuscation of the wing is not confined to the clouds of the cross-veins but fills the costal and two basal cells as well as outlining the course of the larger veins.

One larva of *T. illotus* was collected at Dundurn, Sask., 25.v.1925, together with the larvae of other species but was not identified until pupation had occurred. At a later date, 27.vi.1925, a pupa was obtained from the same locality, and from each of these two a female emerged.



FIG. 11. Pupal aster of *Tabanus illotus*, O.S., ♀.

The *pupa* is brownish yellow, the thorax darker than the abdomen, and measures 18 mm. in length and 4 mm. in diameter. The girdle of spines that encircles abdominal segments 2 to 7 is double dorsally and laterally, single ventrally. Of the dorsal series the anterior row consists of short, stout, strongly chitinated spines that, like the more elongated slender ones of the posterior row, increase in size posteriorly. The dorsal and lateral tubercles of the aster (fig. 11) are elongated and subequal, the ventral smallest, stump-like. The well developed dorso-lateral comb is furnished with four or five elongated spines, and the prominent lateral comb has four short stout ones.



***Tabanus insuetus*, O.S.**

The *adult* of this species is distinguishable from all other western Tabanids by the olive-green eyes traversed by a single purplish-brown stripe in life in both sexes, which are readily associable. The two basal segments of the antennae are greyish yellow. The annulated portion of the third segment is black, the broad basal section brownish black or reddish brown in the female, pale yellowish in the male with a tuft of black hairs at its upper angle. The frontal callosity is shining black, does not extend the breadth of the frons and is overlaid by a black spot above near the middle of the greyish yellow frons. The ocelligerous tubercle is absent. The face is yellowish grey clothed with white hairs. The black ground-colour of the thorax is partly obscured by grey pollen, which is less dense in the male and is traversed anteriorly by slightly perceptible grey lines. The dorsum is invested by a mixture of pale golden and black hairs. On the abdomen above there are three rows of yellowish grey spots, more prominent in the female, which are separated from each other by two median rows of black spots. The underside is uniformly yellowish grey. The membrane of the wing is hyaline, with the costal cell and stigma tinged with brownish yellow, which shades the whole wing in the male. From the basal angle of the anterior branch of the third vein there projects a spur of variable length, often differing in the two wings of the same individual and frequently absent, as in some males examined. Typical specimens are seldom collected in the field, the pubescence being readily removed, leaving the thorax and abdomen greyish black. Females have been taken whilst biting both live-stock and human beings.



FIG. 12. Pupal aster of *Tabanus insuetus*, O.S. ♀.

The *full-grown larva* (Pl. ii, fig. 2) is yellowish white and measures 24 to 25 mm. long and 4 mm. broad. A conspicuous tuft of reddish hair arises from the head capsule on either side dorsal to the base of the antenna. The prothoracic segment tapers anteriorly, where it is encircled by a broad collar of yellowish pigmented pubescence, from which there pass posteriorly a pair of fairly broad lateral stripes on either side and an unpaired narrow medio-ventral stripe. A similar but less extensive band surrounds the anterior margin of the second and third thoracic segments, from which four narrow lateral stripes extend posteriorly on either side. None of these stripes reaches the intersegmental furrows behind. The first thoracic segment is practically unstriate, as are the dorsal and ventral areas of the second and the ventral area of the third. The dorsal area of the third is but slightly striated, whilst the striae of the lateral areas of the second and third are well defined. The lateral areas of each abdominal segment except the anal are more finely striated than the dorsal and ventral. The pubescence of the prolegs and pigmented annuli is greyish or yellowish white and extremely minute. The anal segment (Pl. ii, fig. 10) is subglobular and almost smooth, except for a few irregular striae dorsally and some widely separated

in the ventral region posterior to the anus. The anal area, including the paired lateral, anterior and posterior protuberances, is invested with greyish-yellow microscopic pubescence, from which there extends dorso-laterally a basal band that sends back two broad lateral stripes on either side, terminating just short of the narrow collar, which surrounds the base of the siphon. The latter is finely striated and projects but slightly beyond the end of the segment.

The *pupa* (Pl. iv, fig. 4) is pale yellow with dark markings that appear on the head and thorax as development proceeds. It measures 16 to 17 mm. in length and 4 mm. in diameter. The paired rugose tubercles between the bases of the antennae are well defined, and the paired frontal setiferous tubercles are also prominent. The tubercle of the thoracic spiracle is ferruginous, its rima hooked anteriorly in the male but devoid of hooks in the female. A double girdle of spines encircles abdominal segments 2 to 7, increasing in length up to the seventh. In both sexes the lateral tubercles of the aster (fig. 12) are the largest, extending laterally and slightly dorsally. In the female the dorsal tubercles are closely approximated and about equal in size to the ventral. Their extremities lie in line with those of the lateral or slightly below. In the male the dorsal tubercles are larger than the ventral, more divergent, their extremities reaching above those of the lateral. No trace of dorso-lateral or lateral combs is discernible in the female, whilst both are present in the male, although in a reduced condition, each bearing four vestigial spines.

### ***Tabanus lasiophthalmus*, Macq.**

Two pupae, male and female, were found in a swamp at Onah, southern Manitoba, on 4th June 1925, and from the former an adult was reared on 16th June. The female pupa died and was preserved. All stages of this species have been described by Hine (1906, p. 22), from whom the following account of the adult and larva is borrowed:—"The *adult* measures from 13 to 15 mm. Eyes pilose, ocelligerous tubercle present, wings hyaline, cross veins and furcation of the third vein margined with brown, abdomen broadly red on the sides, female subcallus denuded and shining black, frontal callosity also shining black, as wide as the front and separated from a denuded spot above by a pollinose interval, front slightly widened above; male subcallus not denuded, eyes very plainly pilose, head about equal in size to that of the female.

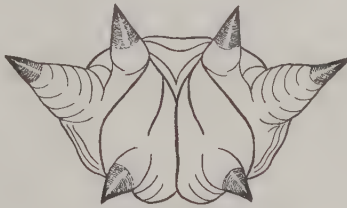


FIG. 13. Pupal aster of *Tabanus lasiophthalmus*, Macq., ♀.

"The *mature larva* is not notably different from those of other species of *Tabanus* so far as form and appearance are concerned. The colour is a dirty white with a pinkish shade over most of the body; the prolegs are not so prominent as in many species, and on this account specimens appear somewhat maggot-like. On either side of the body is a longitudinal row of very small black spots or specks, one to each segment and located just above the ventral prolegs; these spots are lacking on some of the anterior and some of the posterior segments; their presence appears to be characteristic of the species, at least so far as my acquaintance with different larvae goes. Mature specimens are about 25 mm. in length."

The *pupa* (Pl. iv, fig. 5) is a dusky brown with head and thorax almost black in mature specimens. It measures 19 mm. in length and 4 mm. in width. The paired transverse rugose and frontal setiferous tubercles of the head stand out prominently. The rima of the thoracic spiracle bears a distinct hook at its anterior end only. The girdle of spines on each of abdominal segments 2 to 7 is well developed. On segments 4 to 7 the posterior row of the double dorsal series consists of stout short denticles with expanded bases. In the aster (fig. 13) of both sexes the lateral tubercles are by far the largest. The dorsal are slightly larger than the ventral in the female, but the two are of equal size in the male. The dorso-lateral and lateral combs are equally developed in both sexes, each bearing about six fairly stout spines.

### ***Tabanus nivosus*, O.S.**

This rather handsome species seems to enjoy a fairly wide distribution. It was described originally by Osten Sacken from specimens collected in New Jersey. In the present investigation both sexes have been reared from larvae obtained from Saskatoon, Dundurn and Leask, in central Saskatchewan, and from Douglas and Baldur Lakes in southern Manitoba. It has frequently been captured biting human beings and horses. Hine (1903, p. 52) found it to occur at Sandusky, Ohio, and presents the following description by which it may be readily identified:—"Length 12-14 mm. Palpi pale yellow, antennae black, five narrow grey stripes on the anterior part of the thorax, these are obsolete behind; wings hyaline with brown veins, legs black, tibiae more or less reddish; abdominal segments above with very narrow grey hind borders which expand into small grey triangles in the middle, prominent grey markings on the sides of the segments, these markings get smaller from before backwards, and outwardly from them on each side is a row of black spots which vary in size in different specimens.

"*Female*: Sides of the front parallel, frontal callosity brown, nearly as wide as the front, and above with a linear prolongation which reaches half-way to the vertex.

"*Male*: The two sexes are easily associated but the male usually has most grey on the abdomen."

The *full-grown larva* (Pl. ii, fig. 3) is yellowish white and measures 30-34 mm. long and 4-5 mm. in diameter. The head-capsule is ferruginous, the anterior dorso-lateral tufts golden-brown and the individual hairs tipped with black; the mandibles are brownish-black. A narrow collar of greyish yellow pigment encircles the anterior margin of the prothorax, faint traces of which may extend back along the paired lateral furrows. In this respect the prothorax is unique, no pigmented annulus being present on any other segment. The dorsal and ventral areas of all thoracic and abdominal segments, save the anal, are smooth; the striae on the lateral areas are fine except those of the prothorax, which are rather coarse and widely separate. The anal segment (Pl. ii, fig. 11), except the region of the anus, is wholly striated, the rather widely separated striae converging to the constricted posterior third, where they attain a fineness little less intense than those of the tubular siphon. The latter extends one-third of the length of the anal segment, is exsertile and bears near its extremity a few golden-yellow hairs. The prolegs are short, equipped with pale yellow setae, some of which are tipped with black. The anterior and posterior semi-circular anal protuberances are invested with brownish black setae, those of the posterior being particularly coarse. Above the lateral angle formed by the meeting of these two protuberances there is on either side a small patch of fine golden-yellow pubescence.

The *pupa* (Pl. iv, fig. 1) is yellowish brown, changing to brownish black as development proceeds. It measures 21 mm. in length and 4.5 mm. in diameter. The rugose transverse tubercles between the bases of the antennae are slightly oblique, converging mesially like the arms of a V. Above them the paired setiferous tubercles are rounded



oblate, wrinkled at their bases. The tubercle of the prothoracic spiracle is prominent, black and irregularly wrinkled on its lateral face, the arc-shaped rima is abruptly down-curved anteriorly and also strongly recurved to form a hook that is insignificant or absent posteriorly. The tubercles of the abdominal spiracles are appressed. The spinous girdles of the abdominal segments consist of golden-yellow bristles, short on segments 2, 3 and 4, but increased in length on segments 5, 6 and 7. The tubercles

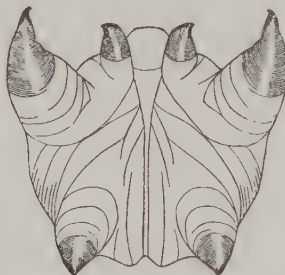


FIG. 14. Pupal aster of *Tabanus nivosus*, O.S., ♂.

of the aster (fig. 14), which is very similar in both sexes, are short, broad basally and black at their extremities; the lateral (directed dorsally) are the largest, the dorsal and ventral subequal. In the female the apices of the dorsal tubercles lie above the line joining those of the lateral; in the male they lie below this line. The coxcomb-like dorso-lateral and lateral fringes are equally developed in both sexes, the spines of the former being more elongated and slender than those of the latter, which suggest thorns. The number of spines in both combs is variable, about 9 in the dorso-lateral and about 6 in the lateral.

### ***Tabanus phaenops*, O.S.**

In the Canadian National Collection, Ottawa, this species is represented by specimens from Banff and Laggan, Alberta. Hine (1904, p. 241) gives its distribution as extending from Alaska and British Columbia to California, including Wyoming and Colorado. McDunnough (1921, p. 143) expresses a doubt as to whether *T. phaenops* can be definitely separated from *T. sonomensis*, O.S., from which it chiefly differs in the absence of a brown spot on the cross-vein. This author (*loc. cit.*) remarks upon the comparative paucity of the species in Canada, and certainly it is not abundant on the prairie, where only two specimens have so far been encountered by us. One of these was a male, measuring 12 mm., which was reared from an undetermined larva collected at Floral, near Saskatoon, on 9th June 1923, along with several larvae of *T. septentrionalis*. It pupated on 18th June, and the imago emerged on 4th July, dying in a teneral condition the following day. The facets of the compound eyes were remarkable in that they displayed a curiously irregular arrangement, upon which comment was passed by Dr. J. M. Aldrich, Associate Curator of Insects, United States National Museum, Washington, D.C., to whom the specimen was sent. It was tentatively identified as *T. sonomensis*, O.S., by Mr. C. H. Curran, Entomologist in charge of Diptera, National Collection, Ottawa, to whom it was originally submitted. Owing, however, to a lack of males, with which a comparison might be made, a doubt was expressed as to the correctness of the identity. The specimen was then submitted to Prof. J. S. Hine, by whom it was referred to *T. phaenops*.

The second specimen was a female, which was taken on the wing at Beaver Creek, 10 miles south of Saskatoon on the South Saskatchewan River, on 22nd July 1917. This specimen was also determined by Prof. Hine, and with the exception of the characters of the eye the two sexes appear to be readily associable. The following is

the description of Osten Sacken (1877, p. 217) :—"Female : Greyish-black ; sides of the abdomen red ; wings hyaline, no distinct brown cloud on the bifurcation of the third vein ; antennae black. Length 13-14 mm.

"Front grey, a little converging ; ocellar tubercle distinct ; callosity nearly square, with a spindle-shaped prolongation above ; antennae black ; third joint rather narrow, its upper angle very little projecting ; thorax greyish-black, with the usual lines very faintly marked ; the antealar callosity variable, reddish or dark. The black stripe inclosed between the reddish sides of the abdomen is generally rather broad, and somewhat expanded at the posterior margins of segments 2 and 3, so as to appear jagged ; the red on the sides of segments 2, 3 and 4 is clothed with a scarce and very minute golden-yellow pubescence, in the shape of faint, oblique spots ; it also forms a fringe on the incisures.

"*T. phaenops* is very like *T. sonomensis*, but it is usually a little smaller, the front is narrower, the bifurcation of the third vein is not clouded ; in most, but not in all specimens, the red on the sides of the abdomen is less extended, leaving a broader black stripe in the middle, which is expanded at the abdominal incisures, and therefore appears jagged. In shape, the abdomen is more elongated, with more parallel sides. In life, this species is easily distinguished by the colour of its eyes, which are of a very bright green, with comparatively narrow purple cross-bands, much narrower than the green intervals between them ; no purple in the upper and lower corners of the eye (at least, in the specimens observed). *Hab.*—Webber Lake, Sierra County, California, 27th July. Four females. Two specimens from Fort Bridger, Wyo., 4th August, seem also to belong here."

A comparison of the single male specimen reared by us shows that the coloration and the pattern of the eye in this sex is very different from that of the female as stated by Osten Sacken above. The ground-colour of bright green is replaced by a dark purplish-blue, which is traversed by a single broad band of bronzy green, divided laterally into two limbs, of which the upper proceeds to the dorsal margin. The irregular arrangement of the facets, which lend a punctate or granular appearance to the eye, may be abnormal. It has not been observed in any other species of male Tabanid examined by us.

The pre-imaginal stages and habits have been described by Webb & Wells (1924), who found *T. phaenops* to be the most abundant species during their investigation of the TABANIDAE of Antelope Valley, which is situated partly in California and partly in the adjoining State of Nevada. A comparison of their description of the full-grown larva with that of *T. septentrionalis* given below (p. 79 and Pl. i, fig. 9, Pl. ii, fig. 5, Pl. iii, fig. 10) reveals a very close resemblance between the two species, which is likewise borne out by the pupa. In my single specimen the latter is yellowish brown and measures 16.5 mm. in length and 4 mm. in width. Of the tubercles that compose



FIG. 15. Pupal aster of *Tabanus phaenops*, O.S., ♂.

the aster (fig. 15) the two lateral teeth are larger than the others and are arranged almost in a straight line with the two dorsal teeth as is the case in *T. septentrionalis* (fig. 18). In other characters also the two species are not easily separable.

***Tabanus reinwardtii*, Weid.**

This species occurs in both eastern and western Canada. In the west it has been recorded from Millarville, in Alberta. All of my specimens have been reared from larvae taken in Saskatchewan, at Dundurn and Maple Creek. Despite the abundance of the species as judged by the ease with which the larvae were obtained, the adults have only occasionally been observed in the fields among herbage and never around livestock or human beings. There are no records of its occurrence in Manitoba, but it probably exists there.

In general appearance it reminds one of *T. nivosus*, but the two can be readily distinguished. The frons of *T. reinwardtii* is broader, the callosity black instead of brown and its linear prolongation narrower. The palps are more robust, and the eyes are thickly pubescent, especially in the male, only very sparsely so in both sexes of *T. nivosus*. In the latter, the five grey lines of the thorax are more distinct, and the investing pubescence is greyish white instead of fulvous. On the dorsum of the abdomen the grey markings of *T. reinwardtii* are more pronounced, and the median triangles are more extensive. The lateral black spots are present in both species, but those of the second segment are absent in the male of *T. reinwardtii*. The wing of *T. nivosus* is hyaline, that of *T. reinwardtii* is lightly shaded with brown, whilst the cross-veins and the bifurcation of the third vein are more heavily infuscated with blackish brown.

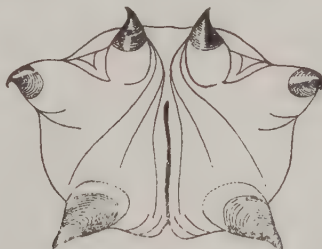


FIG. 16. Pupal aster of *Tabanus reinwardtii*, Weid., ♀.

The egg is brown, black at the extremities, subcylindrical, tapering to either end and measures 2 mm. long and 0.3 mm. wide.

The full-grown larva (Pl. ii, fig. 4) is opaque white and measures 34 mm. long and 4 mm. in diameter. The head-capsule is ferruginous, mandibles black, the anterior dorso-lateral hair-tufts brownish black. The pigmented pubescence is brownish grey, in some specimens yellowish white. The narrow anterior pigmented annulus of the prothorax extends back on either side filling the greater part of the lateral area, and a narrow longitudinal stripe bisects the ventral area. From the anterior annuli of the second and third segments of the thorax four narrow stripes project backwards on either side across the lateral areas. The dorsal and ventral areas of the thoracic segments are smooth, the lateral striated. In the abdomen the lateral areas are more finely striated than the dorsal and ventral. On each segment besides the anterior pigmented annulus there is also a posterior band, which is broadest and best defined on the seventh. The setae of the prolegs are colourless or pale yellowish white, some of them tipped with brown. In the eighth segment the anterior and posterior anal protuberances are invested with coarse brownish-tipped setae, and surrounded by coarse brownish grey pubescence, which extends dorsally and then posteriorly on either side forming an L-shaped mark that barely reaches the pigmented band encircling the constricted posterior third of the segment. Dorso-laterally there is another pair of L-shaped marks (Pl. ii, fig. 7), anterior and mesial to which is a pair of small quadrate spots. The siphon is very finely striate, short, conical and slightly exsertile.



The *pupa* (Pl. iv, fig. 3) is a glossy yellowish or reddish brown and measures 19-23 mm. in length, 4-5 mm. in breadth. The free margins of the paired, transverse, rugose tubercles lying between the bases of the antennal sheaths project prominently. The paired, frontal, setiferous tubercles are deeply wrinkled. The tubercle of the thoracic spiracle is reddish brown, with the lateral face smooth and the rima gently curved and hooked anteriorly. The spines encircling abdominal segments 2-7 occur in double series, those of the anterior row short and denticle-like, those of the posterior row more elongated. On the dorsal surface of segment 7 there are present three wide intervals in the posterior row devoid of spines. The tubercles of the aster (fig. 16) have their pointed tips dark reddish-brown and slightly recurved. The dorsal tubercles are erect, equal in size to the lateral, the ventral being the smallest in the female but almost the equivalent of the others in the male. The dorso-lateral comb (Pl. iv, fig. 17) is equally developed in both sexes, consisting of 4-5 spines and the lateral comb is vestigial in both.

### ***Tabanus rhombicus*, O.S.**

This greyish black species has been recorded from Nordegg, Banff and Waterton, in Alberta; Aweme and Washada, in Manitoba; and Fort Wrigley on the McKenzie River. Only three females have been collected by me in Saskatchewan, two at Saskatoon and one at Gainsboro. On 16th June 1925, a larva was collected in a wheat-field at Indian Head, Sask., by Mr. Kenneth M. King, Dominion Entomological Branch. This specimen pupated on 29th July, and from the pupa there emerged a male on 12th August.

The *female adult* is readily recognisable by its reddish antennae, only the extremity of the slightly-excised third joint being black. The thorax is greyish black with grey lines. On the abdomen above there is a central series of grey equilateral triangles and a lateral series of oblique grey spots, largest and most prominent on segments 2 and 3. The wing is hyaline, with a slight infuscation at the bifurcation of the third vein and cross-veins. In the legs the femora, distal half of the fore tibiae and fore tarsi are black; the middle and hind tibiae are reddish brown.

The *male* is black. The dorsum of the thorax is invested with a heavy erect black pile and a few short golden hairs. The median and lateral markings of the abdomen are less extensive and more greyish golden. The proximal half of the fore tibiae, the middle and hind tibiae and tarsi are brownish black, the remainder being black. The wing is tinged with yellowish brown, and the infuscation of the cross-veins and bifurcation of the third vein is more intensified.

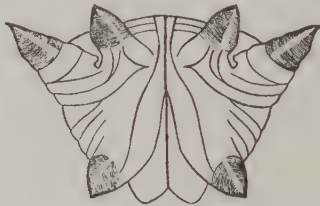


FIG. 17. Pupal aster of *Tabanus rhombicus*, O.S., ♂.

The male *pupa* is dusky brown with black thorax and measures 20 mm. long and 4 mm. wide. The pair of transverse tubercles between the bases of the antennal sheaths is deeply rugose. The rima of the thoracic spiracle is abbreviated and slightly recurved at both ends. The bristles of the double dorsal series of the seventh segment are equally elongated in both rows. In the aster (fig. 7) the dorsal and ventral

tubercles are subequal and somewhat blunted at their extremities, the lateral more elongated and acuminate. The dorso-lateral comb consists of about six spines, of which some may be as long as those of the dorsal armature of segment 7. The lateral comb is vestigial and bears about six aborted spines.

***Tabanus septentrionalis*, Lw.**

This characteristically northern species is the predominant Tabanid of western Canada, extending everywhere through the three prairie provinces of Manitoba, Saskatchewan and Alberta. It occurs also in British Columbia, Yukon and North West Territories, and because of its persistent biting habits is an annoying pest of human beings, cattle, horses and big-game animals.

In the *female* during life the pubescent eyes are a bluish metallic green with three purplish red cross-bands. The antennae are black, the third joint at its base reddish and but slightly excised. The palpi are robust, yellowish white, with a mixture of black and white hairs. The face and cheeks are grey, with yellowish white pubescence. The subcallus is greyish pollinose, and the frontal callosity is black, broad as the frons, which is brown with black and golden hairs. About midway between the callosity and the brownish-black ocelligerous tubercle is an elongated narrow black spot. The brownish grey dorsum of the thorax is traversed by five inconspicuous grey stripes and is invested with an appressed, golden-yellow pubescence mixed with erect black hairs. The ante-alar tubercle is reddish with black hairs, and the pleurae are grey with mixed elongated black and yellow hairs. The dorsum of the abdomen is black, marked with grey spots clothed with appressed, golden hairs, there being a median row of triangles and two lateral rows of oblique marks on segments 1 to 6. The ground-colour of the lateral spots on segments 2 to 4 is often reddish. The legs are black, the fore tibia at its base and most of the middle and hind tibiae reddish. The wings have a dilute yellowish tinge, and a short spur may be present at the base of the anterior branch of the third vein.

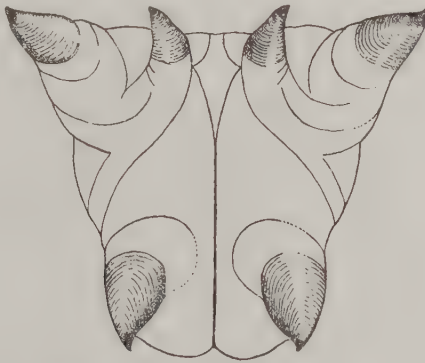


FIG. 18. Pupal aster of *Tabanus septentrionalis*, Lw., ♀.

In the *male* the dorsum of the thorax is black, invested with elongated, erect black hairs and sparse golden hairs. The median triangles are less extensive, being confined to the posterior margins of the segments. The lateral oblique spots are partly obscured by the strong red ground-colour. In some individuals the wing veins and posterior margin are outlined by a greyish brown shading, leaving only the central areas of the cells hyaline.

The *full-grown larva* (Pl. ii. fig. 5) varies in colour from brownish to chlorophyll-green and measures 30 mm. in length and 5 mm. in diameter. The head-capsule is

ferruginous, with reddish dorso-lateral hair-tufts. A brownish grey band encircles the anterior margin of each of the thoracic segments, being deepest on the prothorax. The dorsal and ventral areas of each thoracic segment are smooth and shining, the lateral areas being finely striated. A median furrow bisects the ventral area of the prothorax. The anterior pigmented annulus of each of the first seven abdominal segments is narrow, and on either side lateral to each one of the two dorsal prolegs the pigmented pubescence may extend back as a short stripe to connect with that which fills the interval between the dorsal and dorso-lateral prolegs (Pl. iii, fig. 10). A narrow pigmented band encircles the posterior margin of the seventh segment. The setae of the short stump-like prolegs are pale golden-yellow. A fine brownish pubescence invests the anterior and posterior anal protuberances (Pl. iii, fig. 9), and a narrow band of similar pubescence occurs at the base of the finely-striated, conical siphon. Otherwise, the anal segment is devoid of markings except the occasional presence of a small lateral spot.

The *pupa* (Pl. iv, fig. 8) is at first chlorophyll-green like the larva, changing to pale yellow and finally yellowish brown. It measures 16-18 mm. long and 4 mm. in width. The transverse rugose tubercles of the head are not prominent, and the paired frontal setiferous tubercles are smooth. The thoracic spiracular tubercle is ferruginous with its rima hooked at both ends in the female, anteriorly only in the male. On the dorsal side of the seventh segment wide gaps occur in the posterior row of elongated bristles. In the aster (Pl. iv, fig. 9) the lateral tubercles are the largest in both sexes, the dorsal smallest in the female and equal in size to the ventral in the male. The dorso-lateral and lateral combs are well developed, their spines stout and short with a tendency towards a reduction of both in the female (Pl. ii, fig. 6).

## XII. HYMENOPTEROUS PARASITES OF THE EARLY STAGES.

From a review of the work of previous authors, as collated by Marchand (1920), it is evident that the fund of our information concerning the Hymenopterous parasites of TABANIDAE is comparatively scanty, and, indeed, none other than egg-parasites have, so far, been recorded. Of these, the Proctotrypid, *Phanurus emersoni*, Gir. 1916, was first recovered from an unknown species of Tabanid at Dallas, Texas, and it has more recently been reared from the eggs of *T. punctifer* at Antelope Valley in California and Nevada by Webb & Wells (1924), who also induced it to parasitise, under experimental conditions, the eggs of *T. phaenops*. In Saskatchewan *P. emersoni* was found to be a fairly common parasite of *C. moerens* and *C. mitis*, and frequently it was found in mixed infections of the same egg-mass with the Chalcid, *Trichogramma minutum*, Riley, a species that exhibits great variability in the degree of development of the wings. *T. minutum* has not, so far as I am aware, previously been recorded as a parasite of TABANIDAE or any other family of Diptera. The manner of oviposition of both species was observed. Exploring the surface of an egg-mass the parasite would select an egg, into which the ovipositor was adroitly thrust, the chorion presenting but slight resistance, and the operation was then repeated several times with deliberation on other eggs, each new selection being made apparently at random here and there throughout the mass. Practically every egg-mass of *C. moerens* and *C. mitis* collected in the field yielded individuals of one or both of these parasites, of which *T. minutum* proved to be the more abundant. The degree of parasitism of individual egg-masses varied within fairly wide limits from 4 to 36 per cent in the case of *T. minutum* and 3 to 30 per cent for *P. emersoni*.

The adults of both species of egg-parasites continue to emerge throughout the egg laying season of the TABANIDAE, July and August. On an average the completion of development of the parasite requires ten more days than the period of incubation of the host's egg. The fact that the TABANIDAE have but one generation a year and that the egg-laying season is a comparatively short one would appear to postulate



the necessity of a suitable alternate host or hosts, in which the hibernation of the parasite might be effected. It is most unlikely that the adults of *T. minutum* or *P. emersoni* spend an inactive period of about ten months awaiting the return of the Tabanid egg-laying season. In this respect it is interesting to note that *T. minutum* has been recorded from a variety of hosts of Lepidoptera, Coleoptera, Hemiptera and Hymenoptera, and *P. emersoni* will no doubt be found to possess alternate hosts also.

In addition to the egg-parasites just discussed we were also successful in rearing two species of pupal parasites, a fact of some significance in that parasites of Tabanid pupae have not previously been recorded. The first of these, *Diglochis occidentalis*, Ashm., a species of the Chalcid family PTEROMALIDAE, was obtained from the pupae of three distinct species of *Chrysops*, namely *mocrens*, *mitis* and *excitans*. The second, which was reared from the pupae of *C. mitis* and *T. reinwardtii*, proved to be a new species of the Prototrypid family DIAPRIIDAE, of which a description has kindly been furnished for the purposes of this paper by Mr. R. M. Fouts, of Washington, D.C., an authority on the PROCTOTRYPIDAE.

**"Trichopria (Trichopria) tabanivora, new species.**

*"Female.* Length 1.73 mm. Head as long as wide, narrower than the thorax; antennal club five-jointed, not clearly defined, the joint seven being but slightly narrower than eight; pedicel one and one-half times as long as wide, wider but distinctly shorter than joint three; joints three to nine gradually increasing in width, three the longest; third joint a little over twice as long as wide, one and one-half times as long as four; fourth joint about one and one-half times as long as wide, as long as five, six, or seven, slightly narrower than seven; joint eight as long as seven, longer than wide, as long as nine; joints nine, ten and eleven as wide as long, twice as wide as seven; last joint conical, subacute at apex, one and one-third times as long as wide, as wide as eleven; all antennal joints with short pubescence; thorax one and four-sevenths times as long as wide, narrower than the abdomen; pronotum woolly anteriorly; mesonotum subconvex, without a trace of notauli; scutellum with a large fovea at base; within this fovea on each side are two small striated depressions; scutellum without a trace of a carina; metapleura and propodeum densely covered with short white hairs; propodeum with a low conical prominence at base; wings fully developed, a little over twice as long as the thorax; first segment of abdomen about as wide as long, densely covered with rather long white hairs; second tergite one and three-eighths times as long as wide, its anterior edge not cleft or emarginate; segments following the second united about one-fourth the length of the second; abdomen one and one-half times as long as the thorax; black; antennae brown; pedicel yellow; club fuscous; coxae and trochanters rufous; femora brown, yellowish basally; tibiae brown, yellow on basal half; tarsi yellow, the last joint fuscous; wings hyaline.

*"Variations:* The total length varies from 1.30 mm. to 1.73 mm. The specimens from Saskatoon are, with one exception, smaller than the others. The exception is 1.52 mm. in length and agrees in all particulars with the specimens from Maple Creek. The last four abdominal segments may be very short, united much less than one-fourth the length of the second. Most of the specimens from Saskatoon are like this. All of those from Maple Creek are as in the type.

*"Male.* Length 1.70 mm. Head as in the female; antennae five-sixths as long as the entire body; flagellar joints covered with short erect hairs; scape longer than joints two and three united, five-sixths as long as joints three and four united, four times as long as two, one and one-third times as long as three; joint three about four times as long as wide, longer than four, as long as five and six united; four twice as long as wide at apex, emarginate basally; five about one and one-half times as

long as wide, longer than six, as wide as six; joints six to fourteen subequal, distinctly longer than wide; last joint twice as long as wide, conical, acute at apex; fovea at base of scutellum deeper than in the female, longitudinally striate, without depressions laterally: first tergite a little longer than wide; second tergite one and one-third times as long as wide; last five abdominal segments united three-tenths as long as the second; abdomen one and two-fifths times as long as the thorax, as wide as the thorax; scape rufous, darker outwardly; pedicel and fourth joint at base yellowish; flagellum dark brown.

"Variations: The total length varies from 1.38 mm. to 1.70 mm. The specimens from Saskatoon are, with one exception, smaller than the allotype. The exception agrees with the allotype in all particulars.

"Type and allotype locality. Maple Creek, Saskatchewan.

"Other locality. Saskatoon, Saskatchewan.

"Description based on nineteen females and six males. Seven females and one male were reared by Prof. A. E. Cameron from *Tabanus reinwardtii* at Maple Creek. The others were reared by Prof. Cameron from *Chrysops mitis* at Saskatoon.

"Eleven paratypes, nine females and two males in Coll. Fouts.

"No. 1964 in the Canadian National Collection, Ottawa."

*D. occidentalis* appears in June and emergence continues into July. The numbers reared from single pupae are somewhat variable, the lowest figure recorded among thirteen parasitised pupae of the three species concerned being 15 and the highest 34. Correlated with this circumstance is a distinct variation in the size of the parasites, so that where the parasites of a single host are numerous the individuals are correspondingly small. In some cases the reduction in size may be so marked as to lead one at first glance to suppose that one is dealing with an entirely different species. Another interesting feature was noted in the conspicuous sexual disparity among the individuals emerging from any one pupa, the males forming in all cases a marked minority. Each of the thirteen pupae produced but one male to a variable number of females, save in one instance of *C. moerens*, where among eighteen females two males appeared, and another of the same species in which males were entirely unrepresented among 15 parasites produced. A similar disparity, but less marked, was noted in *T. tabanivora*. From a pupa of *C. mitis* 98 individuals were reared, of which 14 were males, whilst from a pupa of *T. reinwardtii* 112 specimens emerged, of which only 10 were of the male sex. In the glass vials in which the parasites were reared it was noted that copulation occurred in *T. tabanivora* almost immediately on emergence, and a tense excitement expressed by active scurrying movements was observed among both sexes during all the time they were kept in confinement.

Mr. H. L. Viereck, Division of Systematic Entomology, Entomological Branch, Department of Agriculture, Ottawa, informs me that species of the genus *Trichopria* have been recorded from larvae and pupae of various Diptera. As in the case of the egg-parasites the choice of suitable alternatives host for both *T. tabanivora* and *D. occidentalis* seems essential, when one considers the comparative paucity of available host larvae or pupae of TABANIDAE at the time of emergence of the adult parasites. During the summer months Tabanid larvae of the early instars are present in the mud at the bottom of ponds and are thus comparatively secure from parasites. Only after they have undergone considerable development do they migrate to the drier margins of the ponds in the spring and early summer of the year following their emergence from the egg and become more open to attack. During the autumn and winter months the pupal parasites must thus necessarily rely upon more accessible hosts of other insect families.

## XIII. ACKNOWLEDGEMENTS.

In concluding this paper the author wishes to express his indebtedness both to the Honorary Advisory Council for Scientific and Industrial Research of Canada and to the University of Saskatchewan for grants in aid of this investigation. In the collecting and rearing of the various species discussed valuable help was rendered by my assistant, Mr. G. Murray MacFarlane. For assistance in the identification of Tabanid species I take pleasure in expressing my gratitude to Prof. J. S. Hine and Dr. J. M. Aldrich. I deeply appreciate also the kindness of Mr. H. L. Viereck, through whose good offices the parasitic Hymenoptera were determined with the aid of Mr. A. B. Gahan and Mr. R. M. Fouts.

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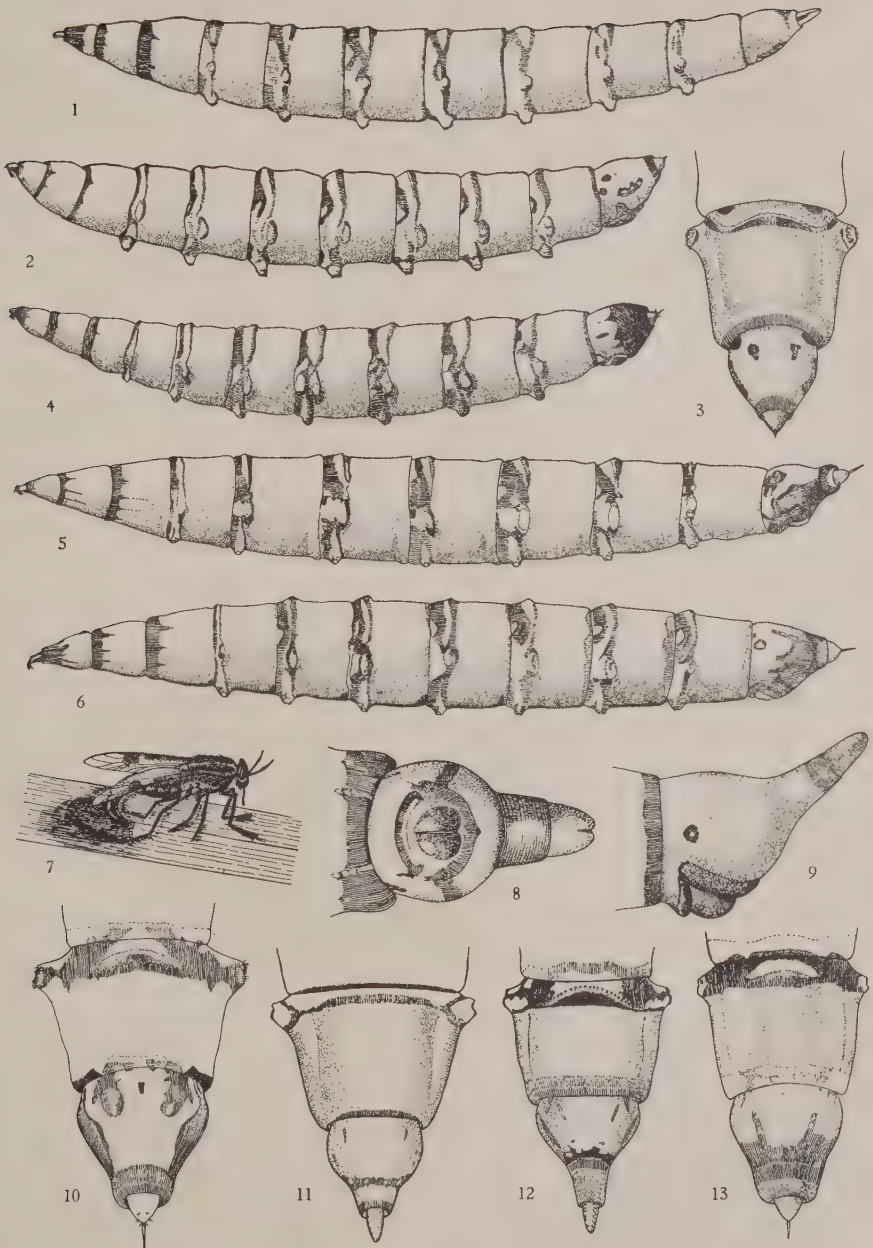
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# EXPLANATION OF PLATE I.

- |      |     |   |
|------|-----|---|
| Fig. | 1.  | <i>Chrysops discalis</i> , Will., larva, $\times 5$ .                             |
| "    | 2.  | " <i>excitans</i> , Walk., larva, $\times 5$ .                                    |
| "    | 3.  | " " siphon of larva, dorsal aspect, $\times 10$ .                                 |
| "    | 4.  | " <i>fulvaster</i> , O.S., larva, $\times 6\frac{1}{2}$ .                         |
| "    | 5.  | " <i>mitis</i> , O.S., larva, $\times 5$ .  |
| "    | 6.  | " <i>moerens</i> , Walk., larva, $\times 6$ .                                     |
| "    | 7.  | " <i>mitis</i> , O.S., adult ovipositing on leaf of <i>Carex</i> , $\times 2$ .   |
| "    | 8.  | <i>Tabanus reinwardtii</i> , Wied., siphon of larva, ventral aspect, $\times 9$ . |
| "    | 9.  | " <i>septentrionalis</i> , Lw., siphon of larva, lateral aspect, $\times 9$ .     |
| "    | 10. | <i>Chrysops mitis</i> , O.S., siphon of larva, dorsal aspect, $\times 10$ .       |
| "    | 11. | " <i>discalis</i> , Will., siphon of larva, dorsal aspect, $\times 10$ .          |
| "    | 12. | " <i>proclivis</i> , O.S., siphon of larva, dorsal aspect, $\times 10$ .          |
| "    | 13. | " <i>moerens</i> , Walk., siphon of larva, dorsal aspect, $\times 10$ .           |





*A. E. Cameron, del.*

EARLY STAGES OF CANADIAN TABANIDAE.

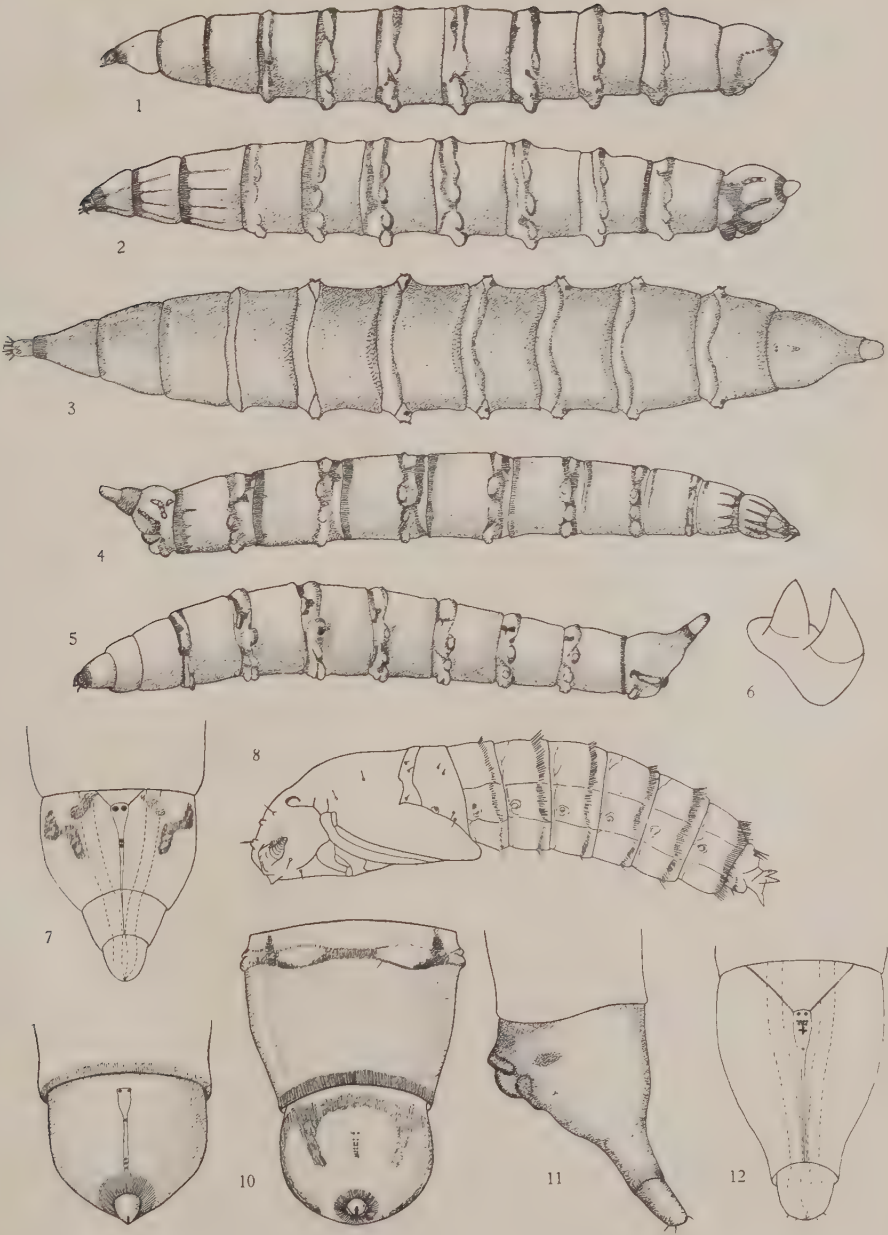




# EXPLANATION OF PLATE II.

- Fig. 1. *Tabanus hirtulus*, Big., larva,  $\times 4$ .  
 „ 2. „ *insuetus*, O.S., larva,  $\times 4\frac{1}{2}$ .  
 „ 3. „ *nivosus*, O.S., larva, dorsal aspect,  $\times 3\frac{1}{2}$ .  
 „ 4. „ *reinwardtii*, Wied., larva,  $\times 3$ .  
 „ 5. „ *septentrionalis*, Lw., larva,  $\times 3\frac{1}{2}$ .  
 „ 6. „ „ dorso-lateral comb of pupa, ♀,  $\times 70$ .  
 „ 7. „ *reinwardtii*, Wied., siphon and organ of Graber,  $\times 7\frac{1}{2}$ .  
 „ 8. *Haematopota americana*, O.S., pupa, ♀,  $\times 12$ .  
 „ 9. *Tabanus hirtulus*, Big., siphon of larva, dorsal aspect,  $\times 10$ .  
 „ 10. „ *insuetus*, O.S., siphon of larva, dorsal aspect,  $\times 10$ .  
 „ 11. „ *nivosus*, O.S., siphon of larva, lateral aspect,  $\times 10$ .  
 „ 12. „ *septentrionalis*, Lw., siphon and organ of Graber,  $\times 9$ .





A. E. Cameron, del.

EARLY STAGES OF CANADIAN TABANIDAE.

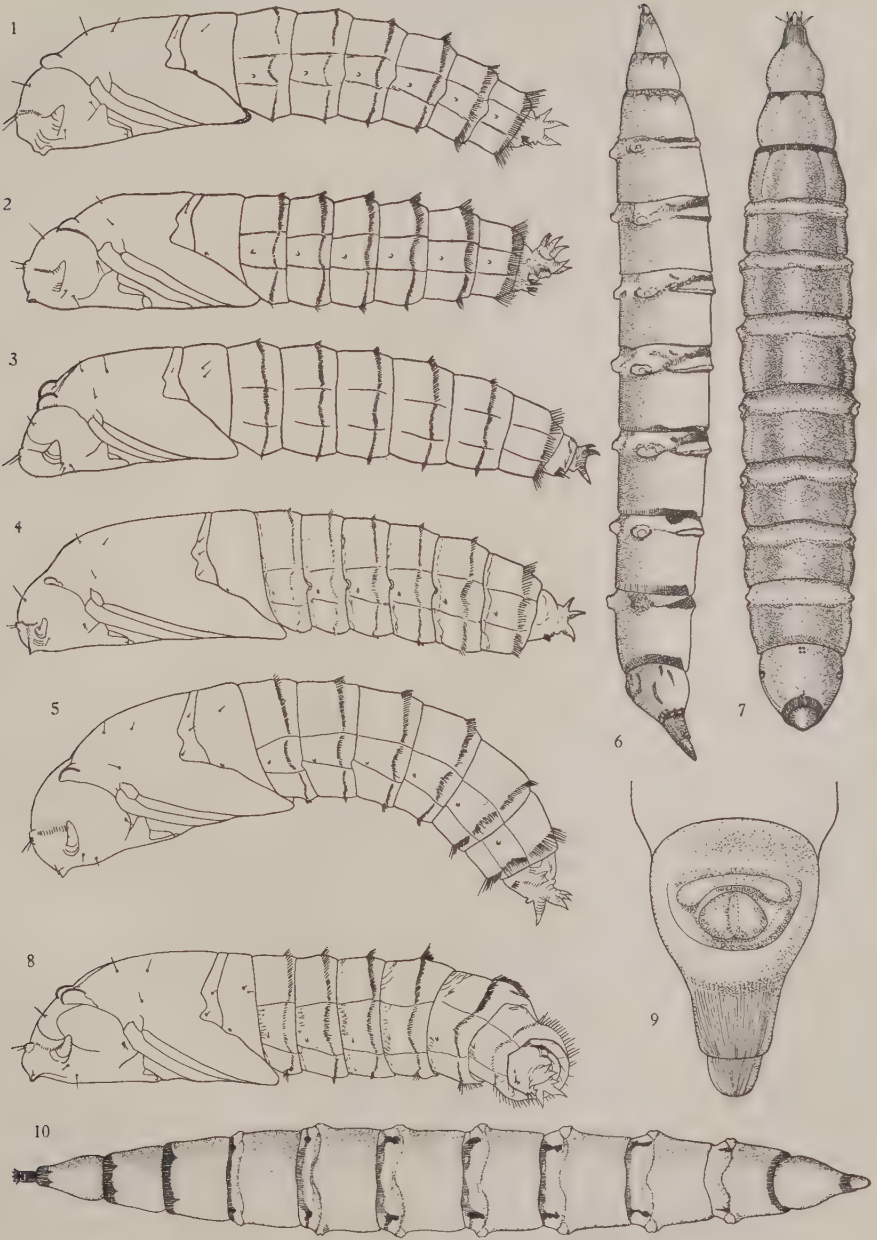




# EXPLANATION OF PLATE III.

- Fig. 1. *Chrysops discalis*, Will., pupa, ♀, ×6.  
 „ 2. „ *excitans*, Walk., pupa, ♀, ×6.  
 „ 3. „ *fulvaster*, O.S., pupa, ♀, ×6.  
 „ 4. „ *mitis*, O.S., pupa, ♀, ×6.  
 „ 5. „ *moerens*, Walk, pupa, ♀, ×6½.  
 „ 6. „ *proclivis*, O.S., larva, ×6.  
 „ 7. *Haematopota americana*, O.S., larva, dorsal aspect, ×5.  
 „ 8. *Chrysops proclivis*, O.S., pupa, ♀, ×6½.  
 „ 9. *Tabanus septentrionalis*, Lw., siphon of larva, ventral aspect, ×9.  
 „ 10. „ „ immature larva, dorsal aspect, ×5.





*A. E. Cameron, del.*

EARLY STAGES OF CANADIAN TABANIDAE.

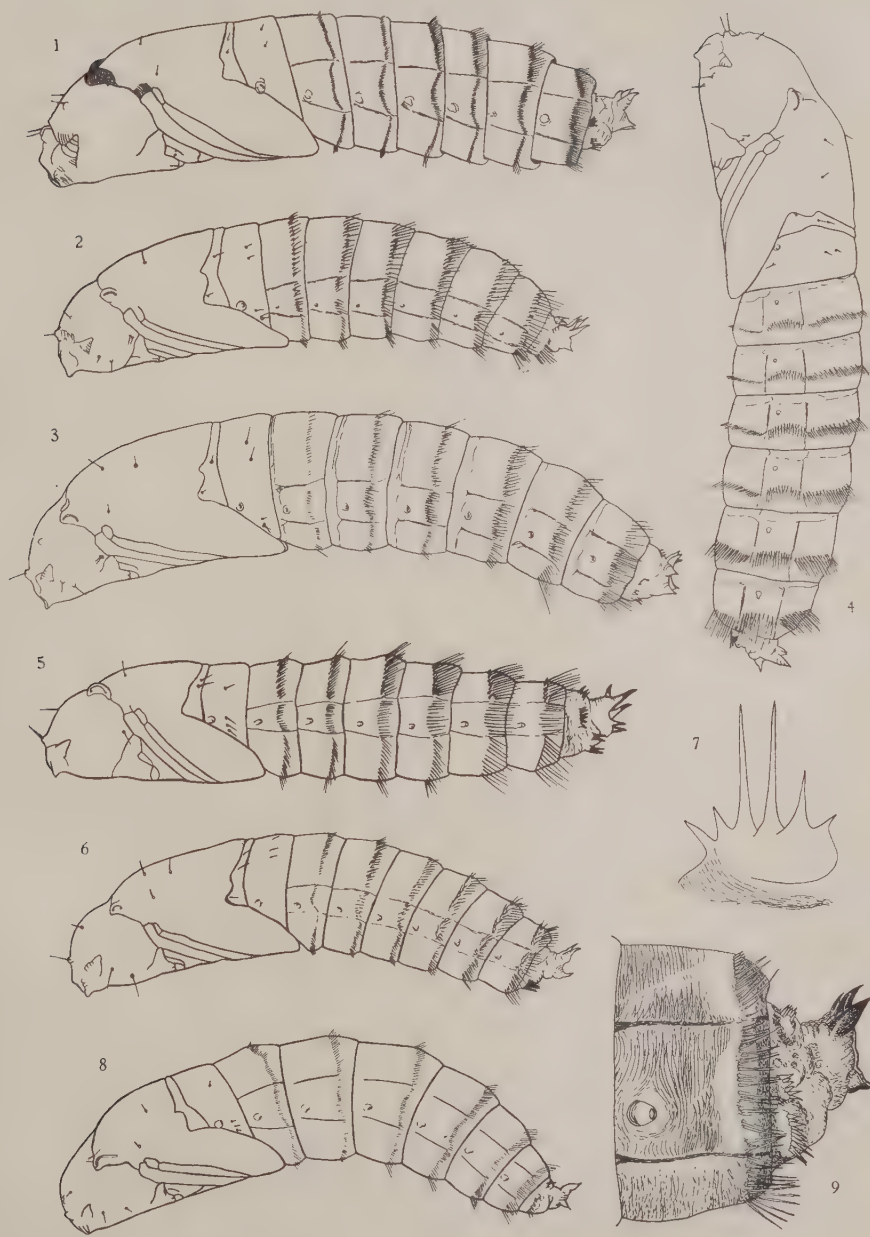




# EXPLANATION OF PLATE IV.

- |      |    |   |
|------|----|---|
| Fig. | 1. | <i>Tabanus nivosus</i> , O.S., pupa, ♀, ×4.                     |
| "    | 2. | " <i>hirtulus</i> , Big., pupa, ♂, ×4½.                         |
| "    | 3. | " <i>reinwardtii</i> , Wied., pupa, ♀, ×4.                      |
| "    | 4. | " <i>insuetus</i> , O.S., pupa, ♀, ×4½.                         |
| "    | 5. | " <i>lasiophthalmus</i> , Macq., pupa, ♀, ×4½.                  |
| "    | 6. | " <i>duplex</i> , Walk., pupa, ♀, ×4½.                          |
| "    | 7. | " <i>reinwardtii</i> , Wied., dorso-lateral comb, pupa, ♀, ×70. |
| "    | 8. | " <i>septentrionalis</i> , Lw., pupa, ♂, ×4.                    |
| "    | 9. | " " pupal aster, lateral aspect, ×12.                           |





A. E. Cameron, del.

EARLY STAGES OF CANADIAN TABANIDAE.



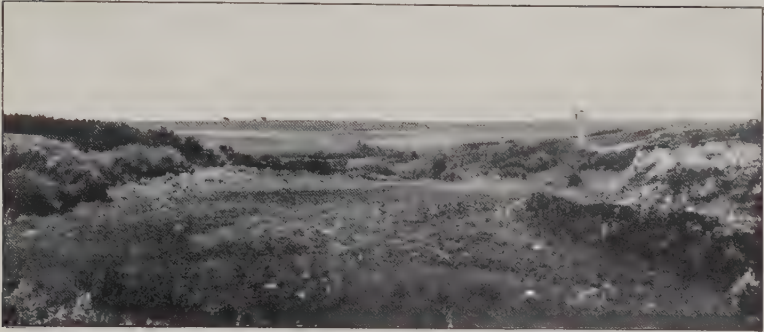


Fig. 1. Marshy ravine near Saskatoon facing the valley of the South Saskatchewan River; breeding place of *Chrysops fulvaster*.



Fig. 2. Bank of a slough near Dundurn, Saskatchewan, where the larvæ of *Chrysops mitis*, *C. mœrens*, *Tabanus hirtulus*, *T. illotus*, *T. insuetus*, *T. reinwardtii*, and *T. septentrionalis* were found.



Fig. 3. Salt lake near Baldur, Southern Manitoba, where the larvæ of *Chrysops discalis* and *Tabanus nivosus* were found.





# A NEW GENUS AND SPECIES OF JASSIDAE INJURIOUS TO MAIZE IN KENYA COLONY, E. AFRICA.

By W. E. CHINA.

The following description is based on material submitted for determination by the Imperial Bureau of Entomology.

## *Cicadulina*, gen. nov.

Allied to *Cicadula*, Zett., but with the venation of the wings as in *Balclutha*, Kirk. Differs from both in having only three instead of four apical cells to the tegmen.

Head including the eyes broader than the pronotum; anterior margin moderately roundly produced between the eyes, vertex being more than half as long as the pronotum in the middle; ocelli distinct, placed on the anterior margin of the head about twice their diameter from each eye; antennae robust, moderately long. Pronotum only twice as wide as long in the middle, the lateral margins not strongly convergent anteriorly as in *Cicadula* and *Balclutha*. Tegmina extending well beyond the apex of the abdomen, with only three apical cells, the outer branch of the first sector distinct and forming the outer side of a more or less distinctly closed cell by its union apically with the outer fork of the inner branch of the first sector. Wings with the venation as in *Balclutha*, that is, with the first two wing veins confluent in their apical third and running into the submarginal vein as one nervure.

In spite of the venation I am inclined to place this genus in the CICADULINI (Baker MS.)

Genotype: *Cicadulina zeae*, sp. nov.

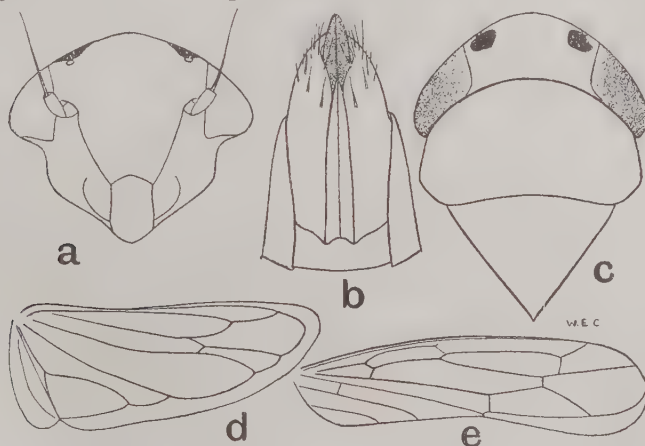


FIG. 1. *Cicadulina zeae*, China, gen. et sp. n., ♀: a, face; b, ventral view of genital segments; c, head, pronotum and scutellum; d, wing; e, tegmen.

## *Cicadulina zeae*, sp. nov.

♀. Deep egg-yellow, paler below, with two large, more or less circular spots, one on each side of the vertex just above (posterior to) the ocelli; the eyes, the dorsum (except the apical tergite), and the apex of the ovipositor, black. Tegmina very pale translucent grey-green, with the nervures very pale yellow. Wings whitish hyaline, with nervures brown. Legs pale yellow, with the spines white, the outer sides of the front tibiae and all the claws infuscate. Last ventrite figured, the spines at the apex of the valves white.

KENYA COLONY: Nairobi, 3 ♀ ♀, on maize, i. 1926 (T. W. Kirkpatrick).



NOTES ON THE GENUS *OXYA*, SERV. (ORTH., ACRID.).

By B. P. UVAROV,  
Imperial Bureau of Entomology.

Grasshoppers of the genus *Oxya*, Serv., are well known to economic entomologists in India and Malaya as pests of rice and other crops cultivated under irrigation. An enormous confusion in systematics of the genus was responsible, however, for gross inaccuracies in records of these pests with regard to the actual species involved in each case. Indeed, no other species except *O. velox* has been ever recorded as a pest, so far as I know, simply because this was popularly supposed to be a most widely spread and common species, while the descriptions of it by different authors were sufficiently vague to enable one to apply the name to almost any species of the genus.

It is, therefore, very important for every economic entomologist in the countries concerned to know that an excellent monograph of all the species of this difficult genus has just been published by Dr. C. Willemse in Holland,\* who collected together for his studies very extensive materials from all the Museums in Europe, including nearly all the types of previous authors. The work has resulted in the recognition of as many as 30 species of *Oxya*, a number of them being definitely recorded as pests; while a clear key to the species, accompanied by careful figures of the morphological details, enables one to identify them comparatively easily, considering the extreme uniformity of the general facies of various species.

This latter circumstance compelled Willemse to pay special attention to the detailed morphology of the external genitalia, and his key, as well as most of his descriptions, are based on those of the female sex only, because they offer better diagnostic characters.

A large work of such a kind cannot be entirely free from faults, and it is with the view of correcting some minor mistakes in Willemse's monograph and rendering it more useful for the economic entomologist that the present paper was undertaken. It is based entirely on the very extensive collection of *Oxya* spp. which was sent to Dr. Willemse by the British Museum and by the Imperial Bureau of Entomology, and which was returned named by him.

As will be seen, most of the corrections are of a formal nomenclatorial character, while there are also one or two cases in which I disagree with Dr. Willemse in his treatment of species.

I may add that the results of Dr. Willemse's work show clearly the necessity of further extensive collecting of *Oxya*, there being probably still a number of undiscovered species of this genus.

***Oxya intricata* (St.).**

1861. *Acrydium intricatum*, Stål, Freg. Eugen. Resa, Insecta, p. 335.

1873. *Oxya intricata*, Stål, Rec. Orth., i, p. 82.

1925. *Oxya universalis*, Willemse, Tijdschr. Ent., lxxviii, p. 21, figs. 12, 13, ♀ (syn. nov.).

1925. *Oxya insularis*, Willemse, t.c., p. 34, figs. 32, 33, ♀ (syn. nov.).

1925. *Oxya intricata*, Willemse, t.c., p. 57, fig. 64, ♂.

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\* Revision der Gattung *Oxya* Serville.—Tijdschrift voor Entomologie lxxviii, 1925, pp. 1-60, 65 figs.

Willemse himself suggested in a footnote to p. 22 that his *O. universalis* is very probably a synonym of *O. intricata*, St., this latter species having been based on a male, while *O. universalis*, like most of Willemse's own species, is based on the female characters. An extensive collection of *Oxya* from the Federated Malay States, sent by the Imperial Bureau of Entomology to Willemse and returned by him named, includes a series of specimens of a species females of which he considered as paratypes of his *O. universalis*. The males in the same collection, which are clearly con-specific with the females, were partly labelled by Willemse as *O. intricata*, partly left unnamed; they agree absolutely with his re-description of Stal's ♀ type of *O. intricata*.

Further, a study of the series of *intricata* shows in several females the presence of a pair of minute and closely approximated teeth on the subgenital plate, which in others seem to be either not developed, or perhaps worn off, the teeth of the ovipositor in the latter group of specimens being also blunted, and partly broken, as an obvious result of wear. The specimens without teeth on the subgenital plate are typical *O. universalis*, i.e., *intricata*, while the others cannot be separated from *O. insularis*, Will., of which I have studied a paratype sent by Willemse. It must be mentioned, by the way, that Willemse in the figure of the latter species omitted to show a pair of parallel keels on the subgenital plate, although he mentions them in the description. Thus, it must be admitted that *O. insularis* is a pure synonym of *O. intricata*.

The very slender general build, pale knees and more elongated fastigium of the vertex, apart from the genitalia, are characters to separate it from *O. chinensis*, with which it is associated in the Malayan rice-fields.

#### ***Oxya siamensis*, Will.**

This species seems to be suspiciously near to *O. intricata*, differing from it in its smaller size and in the keels of the subgenital plate terminating in a minute tooth. The type and three paratypes (two of them males) have been previously preserved in some liquid and are considerably distorted, which makes it hardly possible to arrive at any definite conclusion as to their systematic position. It seems a pity that a new species was based by Willemse on such unsatisfactory material.

#### ***Oxya fuscovittata* (Marsch.).**

Marschall's species was described in 1835 from an unknown locality, but Willemse, who compared the actual type with some specimens of my *Oxya turanica* from Turkestan, found them identical. Since Marschall's type could not have possibly been from Central Asia, a country practically inaccessible at that time, I was inclined to doubt the synonymy. Lately, however, I have found in the British Museum collection a female specimen from Baltistan in India, which agrees in all minute characters with the Turkestan insects, as well as with Willemse's re-description and figure of the type of *O. fuscovittata*. This shows that Marschall probably also received the insect from India.

Lately I have received a good series of this species from various parts of Russian Central Asia, and I can state that the characters of the female genitalia as described and figured by Willemse are perfectly constant. Thus, the difference in the shape of the hind margin of the female subgenital plate in *O. fuscovittata* and in *O. oryzivora*, Will. (from S. India) appears to be a reliable diagnostic character, if not an easy one to appreciate.

On the other hand, the character used by Willemse to separate off *O. fuscovittata* from the group to which *O. oryzivora* belongs, namely, the degree of serrulation of the anterior margin of the elytra, is both insufficiently constant and exceedingly difficult to use.



**Oxya uvarovi**, Will.

This species, described by Willemse from North India (and from Mauritius) is uncomfortably close to *O. fuscovittata*, differing from it mainly in the smaller size and distinctly abbreviated elytra. Willemse gives a further character, in the shape of the male cerci, but a study of my series of *O. fuscovittata* shows that the male cerci in that species vary a good deal and are sometimes quite similar to those of *O. uvarovi*. There being no appreciable difference in the female genitalia of the two species, it seems that *O. uvarovi* may prove to be not different specifically from *O. fuscovittata*. However, more material of *O. uvarovi* must be studied to settle this point.

**Oxya nitidula** (Wlk.).

1870. *Acridium nitidulum*, Walker, Cat. Derm. Salt. Brit. Mus. iv, p. 631  
nec *O. nitidula* (Will. 1925).

1925. *Oxya tridentata*, Willemse, Tijdschr. Entom. lxxviii, p. 30, fig. 27 (syn. nov.).

Coorg, Fraserpet, 29.i.1924 (Fletcher).

The description and figure of *O. tridentata*, Will., fits the type of *A. nitidulum* exactly, while the species which he called by the latter name is really different (see below).

Willemse described his *O. tridentata* from Ceylon and Malabar, and the Walkerian type is from S. Hindostan.

**Oxya bidentata**, Will.

1925. *Oxya bidentata*, Willemse, Tijdschr. Entom., lxxviii, p. 24, figs. 16, 17.

1925. || *Oxya nitidula*, Willemse (nec Walker, 1870), t.c., p. 29, fig. 26 (syn. nov.).

Abbotabad, N.W. Frontier Provinces, 4,120 ft., 6–10.x.1922 (Dutt).

As I just stated, Willemse misapplied the Walkerian name, obviously because he had not seen the type and relied on the apparently insufficient information received from me. At the same time the species described and figured by Willemse as *O. nitidula* cannot be separated from his *O. bidentata* described a few pages earlier; this I am able to say after a careful comparison of the types of *O. bidentata* with the specimens named by Willemse as *O. nitidula* (nec Walk.). The only difference indicated by Willemse is the shape of the hind margin of the female subgenital plate, which should be more acutely prominent in his *nitidula*; but this is a spurious character, since the plate is just as acute in the type of *bidentata*, only the point is somewhat bent and therefore partly concealed between the valvae of the ovipositor. The latter, as well as the male genitalia, are exactly alike in the two insects, and they must be considered conspecific.

**Oxya hyla**, Serv.

1831. *Oxya hyla*, Serville, Ann. Sci. Nat. xxii, p. 287.

1870. *Heteracris viridivitta*, Walker, Cat. Derm. Salt. Brit. Mus., iv, p. 660.

1925. *Oxya viridivitta*, Willemse, Tijdschr. Ent., lxxviii, p. 38.

Willemse adopted for this common African species the Walkerian name apparently because Serville included more than one species in his *hyla*. This fact, however, does not invalidate the name given by Serville, and Kirby (Cat., iii, p. 393) was perfectly right in restricting the name *hyla* to the African species.

*O. hyla* does not differ in the female genitalia from the Indian *O. multidentata*, Will., but the latter is a very much more slender insect with longer elytra; it is not impossible that they are only races of the same species.

**Oxya apta** (Walk.).

1870. *Heteracris apta*, Walker, Cat. Derm. Salt. Brit. Mus., iv, p. 666.

1914. || *Oxya velox*, Kirby, Fauna Brit. India, Acrid., p. 199 (*partim*), fig. 116.

Sylhet, 1 ♀ (Walker's type); Kashmir, Srinagar, 5,200 ft., viii.1923, 1 ♀ (*Fletcher*).

Willemse omitted this species from his revision, as he was unable to examine the type. In his key to the species *O. apta* comes close to *O. grandis*, from which it differs by its smaller size and by the widely separated teeth of the female subgenital plate.

Kirby figured the type of *O. apta*.

**Oxya chinensis** (Thunbg.).

1815. *Gryllus chinensis*, Thunberg, Mém. Acad. Sci. St. Petersb. v. p. 253.

1824. *Gryllus chinensis*, Thunberg, op. cit. ix, pp. 398, 419.

1870. *Acridium sinense*, Walker, Cat. Derm. Salt. Brit. Mus., iv. p. 628.

1873. *Oxya chinensis* var. *a*, Stål, Rec. Orth., i, p. 82.

1925. *Oxya sinensis*, Willemse, Tijdschr. Ent. lxxviii, p. 49, figs. 54-57.

Willemse says in the preface of his paper (t.c. p. 3) that *O. chinensis*, Thunbg., var. *a*, (as named by Stål) is synonymous with *O. sinensis* of Walker. In the text, however, he retained the Walkerian name for the species on the ground, which he explained in a letter to me, that he did not feel justified in restricting the name given by Thunberg to one particular form. In fact, of course, he, as a reviser, was at liberty to restrict the application of the name, and I think it will save confusion later if the synonymy of the species as given above (with further synonyms of *sinensis* quoted by Willemse) is definitely established.

It may be mentioned here that Willemse omitted from his paper altogether two more species described by Thunberg, viz., *lutescens* and *japonicus*, because he was unable to examine the types. This is a pity, as new synonymy is bound to arise when the types are examined.

NOTES ON THE INSECTS OF THE SEA-GRAPE, *COCCOLOBA UVIFERA* (L.)  
JACQ., IN PORTO RICO AND ADJACENT COUNTRIES.

By GEORGE N. WOLCOTT,

*Entomologist, Service Technique, Port-au-Prince, Haiti.*

To lure tourists to the West Indies, the makers of travel literature are most apt to use for illustrations more or less accurate drawings of the coconut palm, as being the most easily recognisable and distinctive tree of these islands. Not so well-known, but quite as characteristic of their sandy beaches, and probably even more abundant, is the sea-grape with its stiff, erect shoots, its large, stiff, rounded leaves, and the gnarled and wind-distorted trunks of the older trees.

Its common name is the same, in literal translation, everywhere: "uva del mar" in Spanish, "raisin der mer" in French, and sea-grape in English. Its purplish-red "grapes" are much larger than many wild *Vitis* grapes, and sometimes even approach in size those of cultivated species. Each contains a single large seed, and they are produced in elongate cylindrical bunches about a single central stalk, from which they fall when ripe. For children, and for adults who like it, their taste is not too unpleasant, while the cooked fruit may serve as the basis for quite a passable dessert.

The wood of *Coccoloba uvifera* is dark reddish brown, with nearly black linear markings, very fine grained, taking an excellent polish, very hard, heavy, strong and tough. It is highly esteemed for cabinet work.

Although economically and pictorially the sea-grape is considerably less valuable than the coconut palm, from the entomological standpoint it has always been peculiarly interesting to the writer. During the summer of 1925, Santo Domingo, several of the lesser Antilles and Venezuela were revisited, and, in addition to the ostensible purpose of the trip, observations and collections were made of the common insects of sea-grape in each of the countries or islands visited. Such observations were in the nature of a comparison with more extensive notes previously made in Porto Rico, which have been published in a list of insects of that island,<sup>6</sup> and unpublished records in Haiti.

In Porto Rico, the sea-grape is very common and furnishes, directly or indirectly, food or shelter for two dozen or more insects. A number of these occur only in Porto Rico or immediately adjacent islands, while in many cases they are restricted to this particular host-plant.

Probably the most abundant insect of sea-grape, not only in Porto Rico but wherever this plant grows, is one of the Fulgorids, *Petrusina* (*Ormenis*) *marginata*, Brunnich, *Petrusa* (*O.*) *pygmaea*, Fabr., or *Ormenis quadripunctata*, Fabr., which often whiten the stems and underside of the leaves of this and numerous other host-plants. At least four other Fulgorids live on sea-grape in Porto Rico, all much less common, and Mr. F. Muir has determined them as *Tangia* sp., *Thionia* sp., *Cyarda* sp., and *Flatoides* sp. *Flatoides* has broader wings than *Ormenis* and hugs the larger tree-trunks so closely with its bark-coloured wings outspread as to be seldom observed. *Cyarda* also has brownish wings, but so cut away and appressed beneath, and elevated behind, that it resembles a blunt twig or thorn. *Tangia* is Niagara green, with transparent wings, while of *Thionia* one usually finds only nymphs on the underside of the leaves.

Brownish Aphids, accompanied by their numerous parasites, predators and attending ants, are quite often noted on the reddish buds or tender leaves. Although never identified by a specialist, the species is presumably *Toxoptera aurantiae*, Boyer, which is a common pest on the tender growth of citrus, coffee, cacao and many trees.

The mealy-bug of sea-grape in Porto Rico is *Pseudococcus nipae*, Mask., but no other Coccid has been collected on this host there. Merrill & Chaffin,<sup>2</sup> in addition

to *P. nipae*, record *Chrysomphalus aonidium*, L., *Coccus hesperidum*, L., and *Pulvinaria psidii*, Mask., from it in Florida, and the writer noted the latter to be most abundant on it in Montserrat and Dominica.

The Diptera of sea-grape are represented by *Ctenodactylomyia watsoni*, Felt, presumably described from Florida material, with which *Cecidomyia coccolobae*, described by Dr. Mel. T. Cook, while he was in Cuba, from the cone-shaped galls in the leaves, is probably synonymous. Mr. A. Girault described two Hymenopterous parasites, *Eurytoma ctenodactylomyii* and *Neocatolaccus livii* from its galls collected in Porto Rico.

The stiff, woody leaves apparently do not recommend themselves as food for caterpillars, for the only species of Lepidoptera reared is *Dichomeris zingarella*, Wlsm., which Mr. August Busck collected in February 1899, at San Juan, from *Coccoloba*, presumably *uvifera*. In Venezuela, quite large caterpillars, presumably Pyralids, were noted in considerable abundance boring in twigs, but none were reared. In St. Kitts, large branches and exposed roots containing similar tunnels, the entrances of which were marked with much excrement and borings, were noted, but none of the larvae were dug out.

In the spring, one will often find the beach vegetation in Porto Rico alive with enormous numbers of the Oedemerid beetles, *Oxaxis geniculata*, Chev., and *Ananca vittata*, F. Because sea-grape is one of the common plants on the beach, it will have its share of the beetles running over it, but apparently they are otherwise uninterested in it.

When Leopoldo Krug was the German consul at Mayaguez and Dr. Juan Gundlach was collecting insects with him, they sent to J. Weise, together with other material, two Chrysomelids for identification or description. One of them, *Cryptcephalus perspicax*, has since been collected on sea-grape, eating the tender leaves, and even more abundantly on another beach shrub, *Dalbergia hecastophyllum*, and on *Inga vera*, a coffee shade-tree; what appeared to be the same species was found on sea-grape in St. Kitts. The other, *Ochthispa loricata*, has never since been collected in Porto Rico, but specimens that Mr. G. E. Bryant has determined from the description to be this species were very common near Macuto, Venezuela, feeding on sea-grape leaves.

Neither of the Otiorrhynchid beetles (CURCULIONIDÆ) which have been found feeding on tender sea-grape leaves in Porto Rico has this as its preferred host. The beautiful little light green *Pachnaeus roseipes*, Chev., is more often a pest in citrus groves, especially in sandy regions. *Lachnopus curvipes*, F., ordinarily feeds on various weeds, but it has been found feeding on sea-grape, not only in Porto Rico, but also in Santo Domingo, in St. Thomas and St. Kitts. The largest and best known Otiorrhynchid of Porto Rico, *Diaprepes abbreviatus*, L., has never been collected on sea-grape, but in St. Kitts an allied species, *D. famelicus*, Oliv., accounts for at least nine-tenths of the tissue eaten from sea-grape leaves.

The Attelabid leaf-roller of sea-grape in Porto Rico, which the writer described and named *Attelabus coccolobae*,<sup>6</sup> never occurs on any other plant. But it is not confined to Porto Rico, for after an extended search on nearly every individual tree along the coast in St. Thomas it was finally found on one in the interior, at an elevation of 1,200 feet. Near Santo Domingo City, what at first glance appeared to be this species was very common. A more careful inspection, however, shows that the Hispaniolan species has but a single large tooth on the anterior femur, where the Porto Rican species has two; the tooth posterior to the humerus is larger and sharper and the elytra are smoother and less regularly punctured or furrowed. Dr. Marshall identifies it as *Euscelus dentipes*, F. Dr. W. A. Hoffman noted these beetles on the north coast of Haiti at Bayeux (near Cap-Haitien), and apparently it occurs in most of Hispaniola.



The southern part of Haiti and the Barrahona section of Santo Domingo is joined to the rest of the island by the Cul-de-Sac plain, which is nowhere many feet above sea-level and is interrupted by several large saline lakes or inland seas. It is locally called Presque Isle. In the neighbourhood of Port-au-Prince, at the south-western corner of the Cul-de-Sac plain, there are comparatively few specimens of sea-grape; the absence of the sandy beaches where it most often grows doubtless being the limiting factor. But on the south coast of Presque Isle more or less extensive stretches of beautiful white sandy beach appear, and here the sea-grape abounds. Between St. Louis and Cayes its leaves could be seen, even from the speeding automobile, to be chewed and bearing numerous characteristic Attelabid egg-rolls. They were of extraordinary size, and the adults making them proved to be considerably larger than *A. dentipes* and strikingly different. They are even uniformly larger than the common *A. armatus*, which feeds on *Dalbergia* and *Stigmatophyllum*, and always broader, with scarcely a trace of a post-humeral spine. In colour they are a rich mahogany brown, the median and posterior legs light yellow, and the more or less elevated parts of the elytra, especially anteriorly, are golden yellow.

A few specimens of a large *Lachnopus* were also collected feeding on sea-grape at St. Louis, these being black with chestnut legs, and adorned with numerous lavender scales, which, where they were most abundant, formed patches of light blue.

Dr. Wm. M. Wheeler<sup>1</sup> has described the subspecies *ramulorum* of *Myrmelachista ambigua*, Forel, from specimens collected in twigs of *Coccoloba uetiera* and *Bucida taccaros*. These are by no means the trees most often inhabited by this ant, for it is such a serious pest in the coffee groves of Porto Rico that it has received the common name of "hormiguilla." In the mountains it most often lives in the coffee shade-trees, *Inga vera* and *Inga laurina*, sending out colonies which become established in the coffee trees themselves. Hormiguilla-infested coffee trees have characteristic swollen, warty growths at their joints, and they become greatly weakened by the tunnels made by the ants in their trunks and twigs, and also by colonies of the soft scale, *Cryptostigma inquilina*, Newst., and the mealy-bug, *Pseudococcus citri*, Risso, which are cared for by the ants in their galleries. This same scale is found attended by the hormiguilla in *Ficus larrigata*, and mealy-bugs are abundant in its tunnels in sea-grape. Dr. Wheeler collected the hormiguilla only in Vieques Island and at Arecibo and Utuado in Porto Rico, but it was noted by the writer on a sea-grape tree high in the mountains of St. Thomas.

Dr. Wheeler also records *Camponotus ustus*, Forel, and *C. sexguttatus*, F., as nesting in the hollow twigs of sea-grape, both in Porto Rico and in the adjacent smaller islands of Culebra, St. Thomas and St. Croix. Of the latter ant he says: "It uses a small amount of croton in constructing at the end of a broken twig a diaphragm which has a round opening to serve as an entrance. Sometimes the diaphragm is flat, in other cases produced as a cone." Mr. S. A. Rohwer identified as *Camponotus abdominalis* subsp.(?) a large yellow ant that was found by the writer in hollow twigs of sea-grape at Macuto, Venezuela.

The only sawfly known to occur in Porto Rico, *Schizocera krugii*, Cresson (= *S. zadachi*, Dewitz), is so characteristic of sea-grape that only R. H. Van Zwaluwenburg<sup>2</sup> ever found the larvae feeding on anything else, namely, on icaco, another shrub common near the ocean and salty lagoons. The female sawfly is much larger than the male and lays her eggs in clusters, each on end and spaced equidistant from the nearest others. The larvae are a veritable plague when abundant and strip the trees of all their leaves, even the oldest and toughest, so that at times one will see miles of sea-grape shrubbery along the coast completely denuded.

In Venezuela, considerable numbers of small black bees, determined by Mr. S. A. Rohwer as *Trigona ruficrus corvina*, Ckll., were noted hovering about the more tender sea-grape leaves. On closer examination, it was found that they were obtaining

honey-dew from the nymphs of a most abundant Membracid, which Dr. W. D. Funkhouser has determined as *Enchenopa concolor*, Fairm. The Membracids were huddled close together on the terminal buds or the midrib of the tender leaves, and the bees not only collected the honey-dew from the leaves beneath them, but were attempting to squeeze in between them and obtain it directly from the producing nymphs. Even so, the supply was apparently insufficient for their needs, for they were also biting off the edges of the tender leaves and collecting the exuding plant juice directly, without having it clarified by being passed through the Membracids. The leaves beneath were covered with chips which they had bitten from the upper leaves, and as soon as the sap ceased to flow, the bees promptly cut deeper into the leaf tissue. They collected the juice on their legs, for the hind tibiae and the first segment of the tarsus are flattened and distended into plates on which the juice can easily be carried, being hairy only at the margin.

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## Appendix.

## TWO NEW SPECIES OF CURCULIONIDAE (COL.) FROM HAITI.

By GUY A. K. MARSHALL, C.M.G., D.Sc., F.R.S.

Two of the weevils referred to by Mr. Wolcott in the foregoing paper as feeding on *Coccoloba wifera* are new to science, and descriptions of them are therefore appended.

## Subfamily ATTELABINAE.

**Euscelus uviferae**, sp.n.

♂. Integument piceous brown or dark red-brown, the disk of the elytra being for the most part testaceous yellow, with all the punctures dark brown as well as a small transverse patch before the middle between striae 2 and 5, the yellow sometimes less extensive laterally and posteriorly in ♂; the pronotum occasionally with indefinite, paler brown, discal patches: the front legs piceous brown, with the tibiae and base and apex of the tarsi more reddish; the posterior pairs of legs (except the coxae) pale testaceous yellow, with the third tarsal joint darker.

*Head* practically similar in the two sexes, broad, only a little longer than the basal width, very slightly narrowed from the base to the eyes, which do not project laterally beyond the sides of the head; the dorsum with strong separated punctures and curved transverse strigulae, and with a fine median stria towards the base; laterally the strigulae stronger but confined to the basal half, and the punctures more sparse; the forehead with a broad deep median furrow, which is continued shortly behind the eyes, and with a row of coarse punctures on each side. *Rostrum* as long as broad, very strongly dilated at the apex, rugosely punctate, and with a median furrow on the basal area, which is separated from the apical area by a shallow transverse impression; the interantennal piece slightly wider than the forehead. *Antennae* red-brown or yellow-brown, inserted behind the middle of the rostrum, comparatively short and stout, and similar in the two sexes: the funicle with joint 1 half as long and 2 almost as long as the scape, 3 a little longer than broad, 4 as long as broad, 5-7 transverse, the club as long as joints 4-7. *Prothorax* transverse, almost parallel-sided from the base to the middle, thence roundly narrowed to the apex, without any apical constriction: the apical margin broadly and deeply sinuate, the base shallowly bisinuate; the dorsum convex longitudinally and sloping steeply forwards, unevenly and rugosely punctate, many of the punctures being confluent, with an abbreviated median stria and on indistinct curved transverse impression across the middle. *Scutellum* parabolic, half as long as its basal width, convex in the middle and sparsely punctate. *Elytra* a little longer than broad (6.5), subquadrate, with fairly regular rows of deep punctures, which are unevenly spaced in the rows, some of them being confluent, especially towards the sides and apex, where the elytra are subsulcate; the intervals narrow and irregular, int. 9 with a widely spaced row of fine erect setae. *Sternum* rugosely punctate, except in the middle of the metasternum, which is transversely strigose with a few sparse setae, and a spot of dense pale setae at the posterior angles of the metasternum proper; the median coxae rather widely separated, the median furrow of the metasternum continued between them, the anterior margin of the intercoxal process elevated. *Venter* coarsely punctate and strigose throughout, with sparse short recumbent setae at the sides and dense curved erect ones in the middle, which are much longer in ♂ than in ♀. *Legs* finely strigose; the front femora not quite as long as the elytra in ♂, somewhat shorter still in ♀, much inflated, as usual, with a stout angulated subapical tooth in both sexes and a small tubercle beyond the middle of the inner face in ♂; the front tibiae of ♂ strongly curved.

*Length*, 6-6.9 mm.; *breadth*, 3-3.3 mm.

HAITI: St. Louis, on sea-grape (*Coccoloba uvifera*), 10.vi.1925, 2♂♂, 3♀♀ (G. N. Wolcott).

Belongs to Jekel's group *Coscineuscelus*, and in Voss' key (Stett. Ent. Zg. 1925, p. 36) runs down next to *E. pulchellus*, Suffr., from Cuba. That species is distinguished by its different colouration, the rostrum is  $1\frac{1}{2}$  times as long as broad, the joints of the antennae are much longer, the elytra are widest behind the middle, the front tibiae of ♂ are almost straight, etc.

The species referred to above by Mr. Wolcott as *Attelabus coccolobae* belongs to the genus *Euscelus*, and it may be noted that in his original description of the species (Jl. Dept. Agric. Porto Rico, vii, no. 1, March 1924, p. 123) the characters of the sexes were reversed.

### **Lachnopus bellus**, sp.n.

♂. Integument black; the head and rostrum above with rather sparse grey scales having a coppery reflection and a few blue scales on the forehead, below with denser grey scales and a stripe of pale blue-green scales along the lower margin of the eyes; the pronotum with sparse lavender-grey scales, and on each side two patches of pale blue scales, one before the middle and the other near the base (probably sometimes united to form a stripe), and on the pleurae a broad blue stripe above the coxae; the front coxae blue in front and grey behind with a blue patch; the elytra with fairly dense lavender-grey scales dorsally but almost bare at the sides, with the following oblong patches of bright blue scales: at the base of interval 3, one before the middle and another at the apex of int. 5, one before the middle and one at the apex of int. 9, and one below the shoulder; the legs bright testaceous red, with the tarsi darker; the mesosternum with blue patches on the intercoxal process and the basal angle of the epimera, and covering nearly the whole episterna; the metasternum with a broad median basal band, a large triangular lateral patch (extending on to the episternum), and the base of the episternum, blue; the venter with the two basal ventrites almost devoid of scaling in the middle and with patches or bands of blue at the sides and margins, the three apical ventrites with fairly dense setiform grey scales and a small lateral blue spot on the two anterior ones.

*Head* closely and strongly punctate, not transversely impressed; the forehead slightly convex, much narrower than the interantennal space and with a small median fovea; the eyes strongly convex, deepest behind the middle. *Rostrum* about as long as the head, gradually widening from base to apex, as long as its greatest width; the basal half flattened, closely and strongly punctate, with the sides quite vertical; the apical declivity broadly impressed; the scrobes short, very broad and deep, subtriangular. *Antennae* piceous brown, with the scape reaching the base of the eye; the funicle with joint 1 very slightly longer than 2, the remainder subequal, about as long as broad and submoniliform. *Prothorax* broader than long, strongly rounded at the sides, widest before the middle, shallowly and narrowly constricted at the extreme apex; the dorsum strongly convex transversely and slightly so longitudinally, with fine close shallow punctures throughout; the pleurae with large deep separated punctures. *Elytra* narrowly ovate, broadest at the prominent subrectangular shoulders, shallowly constricted behind, with the apices separately rounded, each bearing a short conical tuft of setae, and with a shallow transverse impression on each side of the scutellum; the striae very shallow and quite regular, the punctures becoming much smaller behind; the scales small and almost circular, the setae short, curved and truncate. *Legs* devoid of scales, except for a very few on the tibiae, the femora very strongly clavate; all the tibiae armed internally with short obtuse unequal teeth, the hind pair with a dense fringe of long silky hairs.

*Length*, 7.8 mm.; *breadth*, 3 mm.

HAITI: St. Louis, 1♂, on *Coccoloba uvifera*, 10.vi.1925 (G. N. Wolcott).



## ON SOME NEW GENERA AND SPECIES OF COCCIDAE.

By E. ERNEST GREEN, F.E.S., F.Z.S.

**Beesonia**, gen. nov.

Insects inducing galls. Adult female apparently without limbs or antennae. Mouth-parts obscure. Spiracles large and conspicuous; two pairs, occupying a position close to the posterior extremity. Anal orifice minute, setiferous. Genital orifice sharply defined. Spiracles, anal and genital orifices all included in a densely chitinous area. This dense deposition of chitin renders the interpretation of the characters difficult and prevents any accurate definition of the genus.

Adult male alate; halteres ligulate; antennae 3-jointed, the first two joints short, the third very long; limbs without tibiotarsal articulation; penial sheath long and slender.

Embryonic and second-stage larvae with 2-3-jointed antennae; tibiae very short, tarsi very long; the first stage without definite anal ring; the second stage with a simple beaded ring, bearing short truncate setae.

Third stage with 2-3-jointed antennae; limbs well developed, the tibiae and tarsi normal; dorsum with crowded clusters of pores; anal ring heavily chitinated, surrounded by clusters of pores; anal-ring setae short and truncate.

I have, purposely, confined myself to a somewhat loose definition of this remarkable genus. Further material—if and when obtainable—may throw fresh light upon the characters. Later nymphal stages, connecting the third instar with the apodous adult female, await discovery. Meanwhile, I am quite unable to assign the genus to any of the recognised subfamilies. The adult males bear a slight resemblance to those of *Conchaspis*. But, taking them as a whole, the characters of the several stages and of the adult insects suggest more affinity to the TACHARDINAE. I can detect no points of resemblance to any of the Australian or African gall-making Coccids.

Type, *Beesonia dipterocarpi*, sp. nov.

**Beesonia dipterocarpi**, sp. nov. (figs. 1-4).

Adult female (fig. 1, *a*) large tumid, globular or ovoid, smooth, with a small tuberculate prominence at the posterior extremity; anterior half membranous, translucent, whitish or ochreous; posterior half densely chitinous, deep brown. Length, before maceration, 6.5 to 10 mm. Breadth 4.75 to 7 mm. Owing to the density of the chitin the structural characters are difficult to interpret. No organs of any kind have been detected on the paler (membranous) area. The only notable structures are collected upon and immediately around the small posterior prominence (fig. 1, *b*), and it is evident that, during the growth of the insect, the parts have been subject to displacement. In the centre of this area is seen a broad, sharply defined, sinuous space which I believe to be the genital orifice, with, immediately below it, the small circular anal orifice. On each side of the genital orifice is a funnel-shaped opening, which I suppose to be a spiracle, and at a short distance above and to each side is a pair of much larger and more complex spiracles. Occupying a position midway between these larger spiracles is a group of three inconspicuous organs, the exact nature of which I have been unable to determine. They appear to be sunk within the tissue of the derm. The most central of the three represents, I believe, vestigial mouth-parts; while the other two may be vestigial antennae. The form of the supposed genital orifice varies in different examples. In one (*f*) there is a backward extension at each end; another (*e*) has the extremities deflected forwards; while, in

a third example (*d*), no lateral extensions are noticeable. The anal orifice (*g*) is circular and emits, from within a densely chitinous ring, a close tuft of six long and relatively stout setae. Each of the larger spiracles (*e*) has a semilunar opening, partly masked by a densely chitinous triangular lobe with a minutely dentate edge, and is surrounded by a broad and sharply defined band of multilocular pores. The supposed smaller spiracles are so obscured by dense chitin that their exact structure cannot be determined. The derm, within this area, is pierced by numerous minute pores.

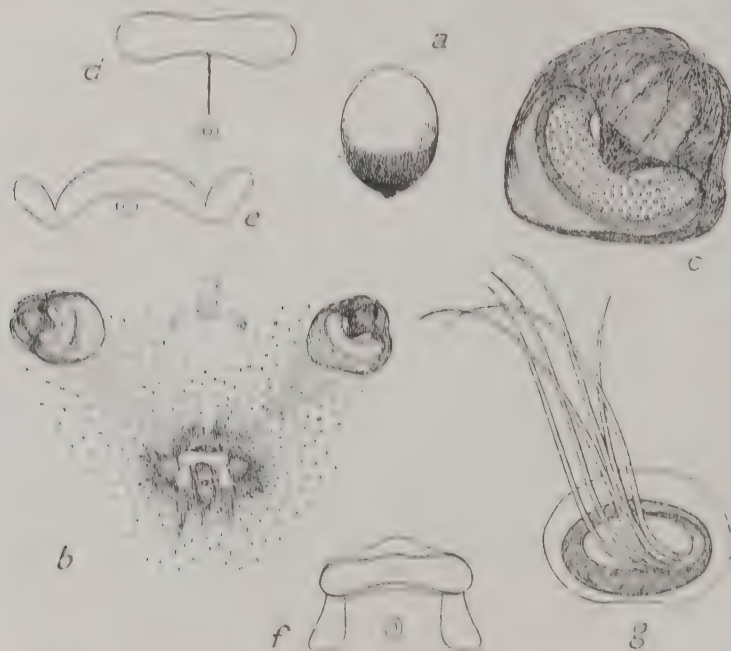


Fig. 1. *Beesomia dipterocarpi*, sp.n.; *a*, adult ♀ removed from gall,  $\times$  about 2; *b*, area round posterior extremity,  $\times$  30; *c*, larger spiracle,  $\times$  80; *d*, *e*, *f*, varying forms of genital orifice,  $\times$  80; *g*, anal orifice,  $\times$  450.

Adult male (fig. 2) alate. The thorax and terminal segment of abdomen heavily chitinised, the remaining abdominal segments membranous; without abdominal spiracles. Head with four large ocelli. Antennae (*e*) 3-jointed, the two basal joints short and densely chitinous; the third joint long and of very irregular form, the apical and basal quarters rigid, the median half membranous, with two or three large rounded prominences, each of which bears from two to four long stout bristles, and with numerous smaller setae. Wings membranous, translucent. Halteres (*f*) ligulate, with a series of short recurved hooks on the rounded extremity. Limbs (*d*) relatively large and robust; tibia and tarsus fused, the point of junction indicated by a slight indentation on the dorsal edge; with numerous short setae; trochanter rather elongate. Terminal segment of abdomen (*b*) with—on each side of the base—a beaded ring (*c*) bearing two long setae which, in the living insect, probably support waxy filaments. Penial sheath long and slender, wider towards the base and somewhat spatulate at the apex (*a*). Length of insect, from frons to extremity of penial sheath, 1.75 mm.



Fig. 2. *Beesonina diptercarpi*, sp.n., adult ♂: a, apex of penial sheath,  $\times 450$ ; b, posterior extremity of body,  $\times 80$ ; c, caudal setae,  $\times 450$ ; d, third leg,  $\times 130$ ; e, antenna,  $\times 220$ ; f, halter,  $\times 220$ .

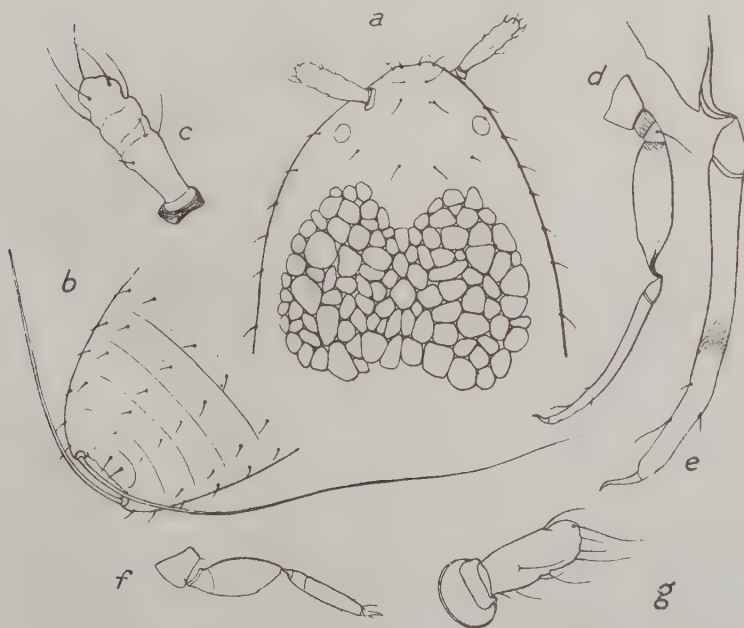


Fig. 3. *Beesonina diptercarpi*, sp.n., embryonic larva: a, thorax,  $\times 220$ ; b, posterior extremity,  $\times 220$ ; c, antenna,  $\times 450$ ; d, third leg,  $\times 220$ ; e, do., tibiotarsal joint,  $\times 450$ . Second stage larva: f, third leg,  $\times 220$ ; g, antenna,  $\times 450$ .

Embryonic larva (fig. 3) elongate ovate, narrower behind. Dorsum of thorax (*a*) with a large, bilobed, more heavily chitinised area, irregularly reticulated with a pattern that may be described as resembling a patch of cobble-stones, the resemblance accentuated by the fact that each space is slightly convex. Antenna (*c*) 2-jointed; the basal joint very short; the terminal joint elongate, clavate and irregularly transversely rugose. Posterior extremity (*b*) with a pair of short rounded tubercles, each of which bears a very long, reflexed, caudal seta; with no definite anal ring. Legs (*d*, *e*) slender; trochanter separated from femur by a membranous area from which arises a longish seta; tibia very short, scarcely longer than broad; tarsus very long, the distal half very weakly chitinised; claw long and slender, recurved at apex. Margin of body with a series of short setae; the dorsum with four longitudinal series of similar setae. Length approximately 0.5 mm.

Second stage larva (observed as exuviae only) with no reticulate area on the thorax. Antenna (3, *g*) 3-jointed; the first a mere slender ring; the second shorter than broad; the third elongate, more than twice as long as broad. Limbs (3, *f*) smaller than in the embryonic stage; tarsus more than twice as long as the tibia; anal ring distinct, consisting of a single circle of cells, with short, truncate cylindrical setae. Length approximately 1 mm.

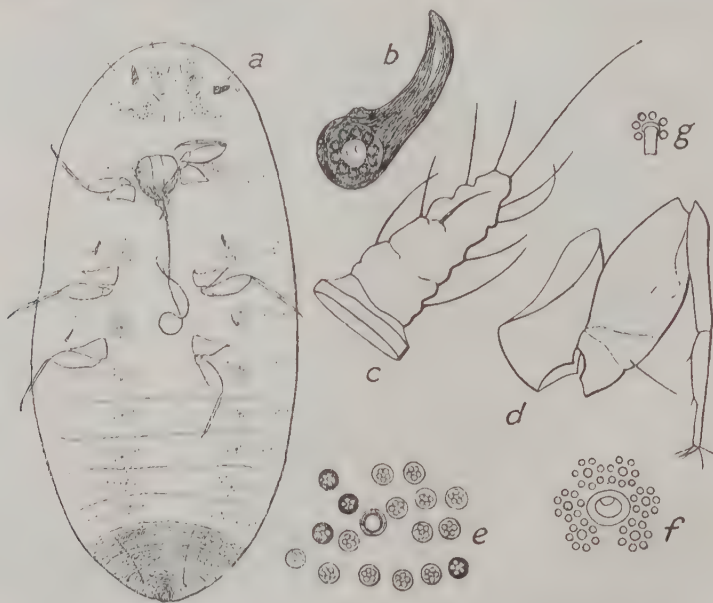


Fig. 4. *Beesonia dipterocarpi*, sp.n., nymph: *a*, insect in optical section,  $\times 50$ ; *b*, anterior spiracle,  $\times 450$ ; *c*, antenna,  $\times 450$ ; *d*, third leg,  $\times 220$ ; *e*, part of one of the dorsal groups of spores,  $\times 450$ ; *f*, anal ring,  $\times 450$ ; *g*, one of the anal setae,  $\times 450$ .

Female of third stage (fig. 4) roseate, thickly dusted with white powdery secretion; elongate ovate (*a*), evenly rounded at both extremities; posterior four segments heavily chitinised, the rest of the body membranous. Antennae (*c*) 2-jointed; the first very short, ring-shaped; the second elongate, broad at base and tapering to the distal extremity, irregularly tuberculate, with about a dozen longish bristle-like setae, one of which (near the middle) is markedly stouter than the others. Mouth-parts large and conspicuous; the labium short; the rostral loop long and contorted.



Limbs (*d*) well developed; coxa and femur robust; tibia and tarsus slender, of approximately equal length; trochanter short, with a broad hyaline area separating it from the femur; claw slender, acutely pointed; digitules simple, slender. Spiracles (*b*) of approximately equal size; cornucopiform; the broad extremity deeply concave, with the aperture encircled by a ring of about ten large and conspicuous pores. Anal orifice (*f*) surrounded by six rosette-shaped clusters of pores, each rosette composed of a ring of seven pores encircling a short, truncate, cylindrical seta (*g*). Caudal setae reflexed upon the venter. Dorsum with two longitudinal series of twelve dense clusters of multilocular pores (*e*) with, near the centre of each cluster, a single larger circular simple pore, the rim of which projects slightly above the surrounding surface; other similar multilocular pores extend, in scattered series, from each of the denser clusters towards the margin of the body and are thickly distributed over the heavily chitinated posterior segments. Many smaller multilocular pores are scattered sparsely over the body. Length 1.5 mm.

The adult female insects occupy cavities in galls at the extremities of the smaller branches of *Dipterocarpus tuberculatus*. The galls are large, irregularly foliaceous, but of a ligneous texture, and appear to be composed of aborted buds and leaves, massed together, with a dense woody base within which are situated the cavities occupied by the insects. Winged males are said to have emerged from the galls, and the earlier stages of the female find shelter in the external crevices of the galls and in irregularities of the bark of the tree.

The material was collected in the forests of Burma by Mr. C. G. Robbins, I.F.S., and was submitted to me by Dr. C. F. C. Beeson, to whom I have dedicated this remarkable new genus.

#### ***Pedroniopsis*, gen. nov.**

Belonging to the subfamily ERIOCOCCINAE. Insects not enclosed in definite ovisacs. Antenna of adult female 3-jointed. Limbs with the tibia shorter than the tarsus. Dorsum and margin of body with series of calcariform setae.

Type, *Pedroniopsis beesoni*, sp. nov.

#### ***Pedroniopsis beesoni*, sp. nov. (fig. 5).**

Adult female (*a*) regularly ovate, evenly rounded in front and behind. Margin with a complete series (of about 110) stout, truncate, cylindrical setae. Dorsum with double medio-longitudinal and lateral series of similar setae; the lateral series single on the abdominal segments; the truncate extremity of each seta roundly excised (*b, h*), except the terminal pair of the median series which are smaller and acutely pointed. Venter with a few minute simple setae. Eyes (*e*) with a sinuous outline, situated close to the margin. Antennae and limbs small. Antenna (*c*) 3-jointed; the first joint shorter than broad, the second approximately quadrate; the third (*d*) elongate, its length equalling or exceeding three times its breadth; with a few longish setae. Limbs (*f*) with coxa and femur robust, tibia and tarsus slender, the latter markedly longer than the former; claw (*g*) rather long and slender; with a minute but distinct denticle close to the tip; digitules simple, slender. Spiracles minute and inconspicuous, situated immediately exterior to the coxae of the first and third limbs, respectively. Anal ring (*h*) dense, very slightly recessed, with six stout setae. Derm without pores, but with (on the dorsum) numerous, small, closely set, chitinous plates of very irregular size and form (see *b, h*). These plates probably are fragments of a continuous chitinous covering which became broken up and dispersed during subsequent growth. The anal tubercles are represented by a pair of larger but equally irregular plates, each of which bears two truncate setae similar to and continuous with the marginal series. Colour of dried examples reddish. Average length 1.5 mm; breadth 1 mm.

Smaller specimens, believed to be examples of the early adult insect, measure 0.65 by 0.4 mm. The dermal plates are contiguous, completely covering the dorsum, and the marginal setae form a close fringe.

The nymphal insect differs from the adult solely in its smaller size and in the reduced number (50 to 54) of marginal setae.

Male unknown, in any stage.

On the bark of *Shorea robusta*. India (Russelkonda, Ganjam, Madras). Submitted by Dr. C. F. C. Beeson.

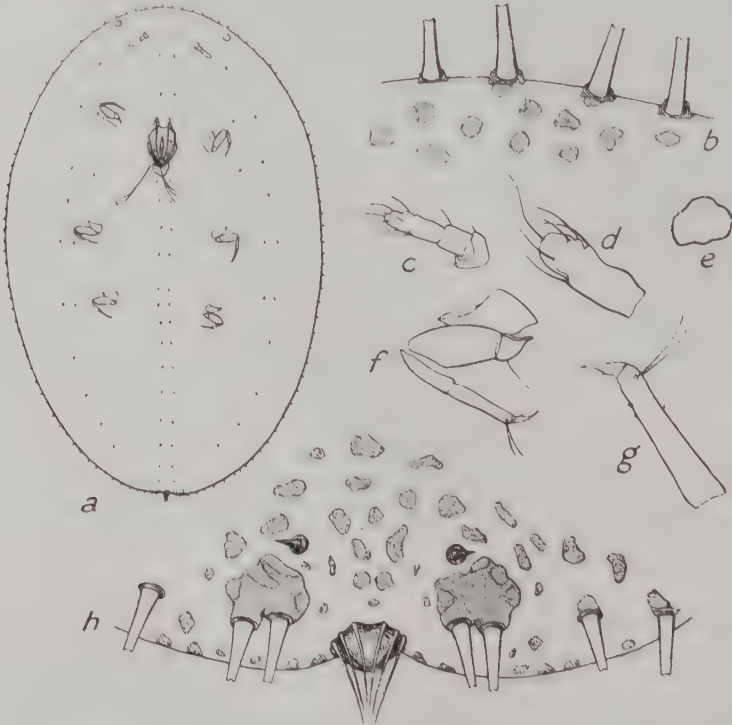


Fig. 5. *Pedroniopsis beesoni*, sp.n. : a, adult, ♀,  $\times 50$  ; b, frons,  $\times 450$  ; c, antenna,  $\times 220$  ; d, do., apical joint,  $\times 450$  ; e, eye,  $\times 450$  ; f, third limb,  $\times 220$  ; g, do., tarsus and claw,  $\times 450$  ; h, posterior extremity,  $\times 450$ .

The insects occupy (and are probably responsible for) cracks and pits in the bark of the tree. Dr. Beeson informs me that they "produce white cottony filaments but are otherwise quite exposed."

Though superficially resembling species of the genus *Pedronia* (a Dactylopiine Coccid), the structural characters, more particularly the relative lengths of the tibiae and tarsi, suggest a closer affinity to the ERIOCOCCINAE.

#### **Eutaxia, gen. nov.**

Insects of the subfamily COCCINAE (LECANIINAE). Having well developed antennae and limbs, the latter of the type found in *Pulvinaria* (to which this genus is probably allied). With anal operculum of the Lecanine type. Spiracles normal. Derm. of dorsum with numerous cribriform plates and calcariform setae.

Type, *Eutaxia moreirae*, sp. nov.

**Eutaxia moreirae**, sp. nov. (fig. 6).

Adult female (*a*) broadly ovate; moderately convex. Dorsum with a dense covering of closely felted white secretion. Margin (*b*) with a close fringe of long, slender, flagelliform setae; without specialised stigmatic setae. Valves of anal operculum triangular; the basal edge shortest, sinuate, the outer edge convex; the inner edge approximately straight, longest. Antenna (*c*) 8-jointed; 6th and 7th shortest; the remainder subequal in length. Limbs (*d*) normal; the tarsus exceeding



Fig. 6. *Eutaxia moreirae*, sp.n., adult ♀: *a*, dorsum,  $\times 30$ ; *b*, marginal setae,  $\times 300$ ; *c*, antenna,  $\times 135$ ; *d*, third limb,  $\times 80$ ; *e*, part of derm, with cribriform plates and calcariform setae,  $\times 450$ ; *f*, one of the cribriform plates, viewed in profile,  $\times 450$ .

half the length of the tibia, inclined outwards; claw rather stout; ungual digitules narrowly dilated at extremity; tarsal digitules slender. Derm of dorsum (*e*) closely and evenly set with thick cribriform plates of varying size, with perforations varying in number from 3 to 15 or more; the spaces between the cribriform plates crowded with small, but robust, fusiform setae. Length 2 mm. Breadth 1.25 mm.

Male puparium glassy, frosted, colourless; divided into median and lateral plates.

On an undetermined shrub. Brazil (Rio Grande do Sul). Submitted by Dr. Carlos Moreira, after whom I have named this interesting species.

The material under consideration appears to be in an early adult stage. No embryos were observed in the bodies of the insects. It is probable that an ovisac, of some kind, might be produced, after gestation.

**Neofurcaspis**, gen. nov.

Puparia similar to those of *Furcaspis*; subcircular, with the posterior extremity often produced; exuviae eccentric; dorsal scale dense and opaque; ventral scale strongly developed.

Adult female with a double series of perivulvar\* pores ; other characters as in *Furcaspis*.

Type, *Neofurcaspis andamanensis*, sp. nov.

***Neofurcaspis andamanensis*, sp. nov. (fig. 7).**

Puparium of female subcircular to subovate ; reddish brown, the margin paler ; exuviae impinging upon the margin, outlined with brighter red, that of the larva with a small whitish central boss. Ventral scale stout. Margin of dorsal scale expanded and flattened ; with sinuous raised lines on the undersurface. Longer diameter 2.75 to 4 mm.

Male puparia of similar form, but smaller and of a brighter red colour. Longer diameter 1.5 mm.

Adult female ovate, broadest across the mesothorax, narrower and tapering behind. Frons and margin of body with scattered longish setae. Vestigial antennae each consisting of a stout chitinous disc, bearing from four to six stout curved setae, three of which are markedly larger than the remainder. Anterior spiracles each with a small group of from 3 to 5 parastigmatic pores. Pygidium (*a, b*) bluntly pointed ; with the apical half rather heavily chitinised, the chitin deposited in irregular



Fig. 7. *Neofurcaspis andamanensis*, sp.n. : *a*, pygidium of adult ♀,  $\times 130$  ; *b*, extremity of pygidium,  $\times 450$ .

longitudinal lines with clear interspaces ; perivulvar pores in twelve small groups, each containing from 2 to 6 pores, arranged in two concentric series, six groups on each side, with no median group, the individual pores relatively small ; margin (*b*) with six prominent, entire, bluntly rounded or truncate trullae †, the length of each trulla slightly exceeding its breadth ; squamulae ‡ ligulate, with concave extremities,

\* " Perivulvar " appears to be a more suitable term than either " circumgenital " or " perivaginal " for the pores surrounding the genital orifice.—E.E.G.

† I have adopted this term, from the Italian writers, to describe the so-called pygidial " lobes."

‡ " Squamulae " is here employed in the place of " plates " or " squames."



situated in the spaces between the trullae only; margin beyond the trullae heavily and irregularly cristate, with many dentate prominences; paraphyses short but pronounced, very numerous, especially along the cristate margin, where they are more or less obscured by the denser chitin; dorsal pores minute, circular, sparse. Length approximately 1 mm; breadth 0.75 mm.

On fronds of *Cocos nucifera*, Andaman Islands (Port Blair, Ross Island). Collected and submitted by Mr. P. V. Isaac.

***Neoleucaspis*, gen. nov.**

Allied to *Leucaspis*, from which it differs, principally, in the complete absence of perivulvar pores. Characters of the nymphal exuviae typical of *Leucaspis*.

Type, *Neoleucaspis parallela*, sp. nov.

***Neoleucaspis parallela*, sp. nov. (fig. 8).**

Female puparium naked, consisting of the larval and nymphal exuviae, without any appreciable secretory appendix; elongate, narrow, with straight parallel sides; colour reddish ochreous, the median area brownish.



Fig. 8. *Neoleucaspis parallela*, sp.n.: a, nymphal exuviae,  $\times 80$ ; b, pygidial margin of nymph,  $\times 450$ ; c, adult  $\varnothing$ ,  $\times 80$ ; d, margin of adult pygidium,  $\times 450$ .

Nymphal pellicle (a) with an elongate, longitudinal, sharply circumscribed, raised median area. Pygidial area sharply separated from the preceding segments by a deep lateral incision on each side. Margin of nymphal pygidium (b) with six

prominent, narrow, obscurely tridentate trullae, their bases inwardly produced into slender paraphyses; squamulae broad and prominent, extending slightly beyond the trullae, the outer side of each pair longer than the inner; with four lunate marginal pores on each side; with no discal pores. Total length of puparium 1.5 mm. Length of nymphal pellicle 1 mm.

Adult female (*c*) elongate, rounded anteriorly, posterior extremity bluntly truncate. The thoracic area rigid, somewhat heavily chitinised and more deeply coloured; sharply demarcated from the abdominal area; with four longitudinal series of elongate, irregularly sinuous, colourless vacuoles. Abdomen membranous and colourless; the pygidial margin (*d*) without lobes, but with (usually) sixteen short but broad squamulae, their distal extremities minutely serrate. Pygidium entirely without perivulvar or other pores; with a median roughened patch. Length approximately 0.75 mm; breadth approximately 0.25 mm.

On *Bambusa* sp. India (Malabar). Collected by T. V. Ramakrishna Aiyar.

### **Hybridaspis**, gen. nov.

Allied to *Fiorinia*. Female puparium consisting of the enlarged nymphal exuviae, with or without a slight secretory appendix. Larval pellicle situated at the anterior extremity, projecting beyond the margin. Nymphal pellicle with the pygidium completely or partially enclosed between two backwardly directed processes from the penultimate segment. Male puparium elongate, narrow, with the appendix more or less prominently tricarinate. Adult female enclosed within the nymphal exuviae; with definite groups of perivulvar pores; margin of pygidium with one or more pairs of trullae, without squamulae and without dorsal pores.

Type, *Hybridaspis producta*, sp. nov.

### **Hybridaspis producta**, sp. nov. (fig. 9).

Puparium of female consisting of the enlarged nymphal pellicle, with the small larval pellicle overlapping the anterior margin; without any appreciable secretory appendix. Larval pellicle (*e, f*) broadly ovate, pale, translucent stramineous, with large dark brown patches occupying the centre of the thoracic and abdominal areas, or with the whole area—except a transverse median and a narrow marginal zone—filled in with dark brown. Nymphal pellicle (*c*) elongate ovate; translucent stramineous, with a large, irregular, median black patch; pygidium almost completely enclosed between a pair of backwardly directed, horn-shaped processes. Posterior extremity of nymphal pygidium (*d*) with a median pair of pointed, coalescent trullae; with no lateral trullae. Length 0.75 mm.

Male puparium (*g*) elongate; larval pellicle brown, with a narrow translucent pale border; appendix whitish, wider posteriorly, weakly tricarinate; length approximately 1 mm.

Adult female (*a*) broadest across median area of abdomen. Mouth-parts large and conspicuous. Vestigial antennae with a single stout curved seta. Spiracles without parastigmatic pores. Pygidium (*b*) with the extremity sharply constricted and terminating in a pair of small, closely approximated, median trullae; with no lateral trullae; lateral margins with two conspicuous pointed prominences, the second of which is irregularly emarginate; spiniform setae rather long and pronounced; with a slender membranous spine on each side of the median trullae, a similar spine on the posterior lateral prominence, another (sometimes absent) immediately caudad of the anterior lateral prominence, and two stouter membranous spines nearer the

base. Anal orifice circular, central, large and conspicuous. Perivulvar pores in five elongate clusters, the median group with 6 pores, anterior lateral groups with from 10 to 12, posterior laterals with from 6 to 11. Total length of insect averaging 0.5 mm.

On leaves and twigs of *Loranthus signatus*. Australia (Darwin, N.T.). Collected by G. F. Hill.



Fig. 9. *Hybridaspis producta*, sp. n.; a, adult ♀,  $\times 50$ ; b, pygidium of adult ♀,  $\times 450$ ; c, nymphal pellicle,  $\times 50$ ; d, posterior extremity of nymph,  $\times 450$ ; e, f, larval exuviae,  $\times 50$ ; g, male puparium,  $\times 18$ .





## THE PINK BOLLWORM OF QUEENSLAND.

By F. G. HOLDAWAY, M.Sc.,

Zoology Department, University of Adelaide, South Australia.\*

(PLATE VI.)

Included among the insects attacking cotton in Queensland is a small pink larva, the adult of which has been regarded as *Platyedra gossypiella*, Saunders. In the following paper an account is given of the present knowledge of this insect.

On 14th April 1924 an announcement appeared in the Brisbane daily press that "pink bollworm" had been discovered attacking cotton in Queensland. A year previously, Mr. G. Evans, of the Empire Cotton Corporation, had found pink bollworms infesting cotton at Broome in West Australia. These were identified as *P. gossypiella* by Mr. L. J. Newman, the West Australian Government Entomologist (March 1923). In the following August similar specimens were collected by Mr. Evans in wild cotton growing in the Roper River region, Northern Territory.<sup>5</sup>

At the time of the reported occurrence in Queensland, a strong effort was being made to re-establish the cotton industry on a commercial scale, and the possibility of the introduction into that State of the pink bollworm or the boll weevil had been constantly in the minds of officials, more especially in view of the recent discoveries in West Australia and the Northern Territory. It was quite natural then that the announcement should cause a stir in agricultural circles throughout the State.

So far as I am aware, the only official mention that has been made of the insect is that by Mr. E. Ballard, Commonwealth Cotton Entomologist,<sup>2</sup> who called the insect *P. gossypiella*, but who more recently<sup>3</sup> has referred to it as a "race" of *P. gossypiella*.

Although it is realised that there is a considerable amount of work yet to be done, it seems that sufficient evidence is already available for considering the pink bollworm of Queensland to be quite distinct from any other known insect, and the invasion of the cotton fields to have been due to an indigenous insect rather than an insect recently imported in seed.

In February 1924 Dr. A. Jeffries Turner was unable to distinguish from *P. gossypiella* some moths bred from larvae attacking cotton at Gladstone, though it was the presence of certain larval differences which led me to submit the adults to him for determination. These larvae were recognised as being similar to some which had been found nearly a year previously in the seed-capsules of *Hibiscus tiliaceus* at Southport in South Queensland, and differed from those collected in West Australia and the Northern Territory and from specimens from Egypt, and, moreover, did not agree with the description of the larva of *P. gossypiella* as given by Busck<sup>4</sup> and Heinrich.<sup>8</sup> Later in the year Mr. Ballard arrived in Queensland and was acquainted with the facts concerning the insect and its near relatives, specimens sent by him to the Imperial Bureau of Entomology were also identified as *P. gossypiella* by Mr. E. Meyrick.

Although characters have not yet been noted whereby the moths may be distinguished from *P. gossypiella*, the differences in regard to the larvae and pupae are sufficiently pronounced to justify the bestowal of specific rank on the Queensland insect, for which the name ***Platyedra scutigera*** is now proposed.

\* Some of the information contained in this paper was obtained whilst on the staff of the Queensland Government Entomologist, and later when assistant to Mr. E. Ballard, Cotton Entomologist to the Commonwealth Government; the more detailed examination of the larvae has been carried out with preserved material since my arrival in Adelaide.

### Early Stages of *Platyedra scutigera*.

*Egg.* The eggs are white to pale cream but later become pink. The pink colour is not uniformly distributed but is localised in patches, particularly round the edges. The egg shows a delicate sculpturing of longitudinal ridges with oblique lines between them, giving the appearance of rows of triangles whose depressed centres produce an iridescence. In shape it is rather flat, very slightly convex, elongate, with blunt ends, one end being usually more rounded than the other, but sometimes it is almost elliptical in outline. The eggs vary in size, from 0.53 mm. to 0.64 mm. long, and from 0.30 mm. to 0.33 mm. wide, averaging 0.56 mm. in length and 0.32 mm. in width, the measurements usually being slightly less in the case of eggs laid in a cluster and slightly more in the case of eggs laid singly.

Just prior to hatching the larva can be seen curled up in the egg with its posterior end approximated to the head, which is placed almost on its side at the blunter end. The dark head-capsule and prothoracic shield can be clearly seen through the chorion. The larva emerges through the end of the egg and leaves an emergence hole with a ragged edge.

No breeding experiments to determine the number of stadia passed through during the larval life of the insect have been carried out, but from the measurements of the head-capsules of a large number of larvae, it would appear that there are four instars.

*First Instar.*—The first instar is white to cream and in the field often appears pale flesh-coloured. The larva is widest (0.25 mm.) at the head and tapers slightly behind. The head is black, with reddish brown mandibles. The prothoracic shield is fuscous and not divided in the middle line. The setae are glassy white, and most of those on the dorsum are swollen distally so that they appear to be tipped with drops of dew. The setae on the head are not swollen. On the abdomen the dorso-lateral setae  $\rho$  are longer than the dorsal, and the lateral setae  $\eta$  are longer than the setae  $\rho$ . Two pairs on the anal segment are longer than any others, being equal in length to the width of the head-capsule, and are not swollen distally. The legs and pseudopods are glassy white. The crochets on the ventral pseudopods are four in number and situated on the lateral edge of the planta, forming what may be called a "latero-series" in contradistinction to a "meso-series." On each of the anal pseudopods there are two crochets, larger than those of the ventral pseudopods, and situated one at the lateral and one at the mesal end of the transverse planta. The crochet formula is thus 4, 4, 4, 4, 2.

Just after hatching the larvae are about three-quarters of a millimetre in length and increase to about 2 mm. before the first moult.

*Second Instar.*—The head-capsule of the second instar is shiny black and has an average width of 0.42 mm. The prothoracic shield is fuscous and undivided in the mid-dorsal line. The setae are white and not swollen distally; on the dorsum they are surrounded at their bases by smooth light-brown chitinated plates or pinacula. The anal shield is fuscous. The body is white with, at least sometimes, a pink tinge surrounding the pinacula on the dorsum.

The legs are white, with the cephalic parts of the bases slightly fuscous. The pseudopods are white, with a slight fuscous plate on the lateral surface of the anal ones. The crochets on the ventral pseudopods are usually four in number, arranged two cephalad and two caudad on the planta, as if situated at the corners of a rectangle. Sometimes there may be as many as six or seven crochets, in which case they are arranged as transverse rows with three or four in each row. On the anal pseudopods there are usually three or four crochets arranged in two groups, *viz.*, two in the lateral and one or two in the mesal group; but there may be as many as five or six, when there are three laterals and two or three mesals.

The larvae range from 3 mm. to 4 mm. in length.

*Third Instar.*—In general appearance the third instar is very similar to the second, but with a definite pink colouration surrounding the pinacula on the dorsum. The head-capsule is very dark brown, almost black, with a maximum width averaging 0.75 mm. The prothoracic and anal shields are fuscous. The former shows indications of the median division that is present in the mature larva, in the posterior region the chitinisation in the median line being less marked than on the remainder of the shield for about one-third of its length. The pinacula are more prominent than in the previous instar.

The legs and pseudopods are white. The number of crochets on each ventral pseudopod may range from six to fifteen according to the size of the planta; the average for five larvae was found to be eight, and the highest average observed for a single larva was thirteen. The crochets are arranged in transverse bands and usually when there is an odd number the anterior row contains more than the posterior. The average number of crochets on the anal pseudopod is seven, arranged in a transverse row divided into two groups, with the larger number laterally. Their number and arrangement on the pseudopods of two typical larvae are given below.

Abdominal Segment.			Crochets.			
3	...	...	4	4	5	5
			3	3	3	4
4	...	...	4	4	4	5
			3	3	4	4
5	...	...	5	4	5	4
			3	3	5	5
6	...	...	3	3	5	5
			3	3	3	3
10	...	...	3:2	2:3	5:3	3:5

The crochet formula to the nearest whole number is 7, 7, 8, 7, 6.

The larvae range from 4.5 mm. to 8 mm. in length.

*Fourth Instar.*—The head-capsule of the fourth instar is very dark brown and often practically black. In specimens which are dark brown a vaguely defined pattern of darker and lighter areas can usually be made out (fig. 1, B). The most prominent lighter areas are a pair of oblique bands across the vertex, one on each side, running obliquely forward towards the arms of the epicranial suture. Anterior to this main one on each side is a second narrower, less distinct band approximately parallel to the main band. A third indistinct band can sometimes be made out, anterior to the other two. The greatest width of the head-capsule is just anterior to the middle and averages 1.28 mm. The pre-clypeus is pale yellowish, the labrum brown, and the mandibles very dark brown. The antennae are light brown, the submentum and basal sclerites of the maxillae whitish, and the other trophi pale brown. When viewed from above the lateral margins of the vertex appear almost parallel for part of the length; this gives each lateral portion of the vertex an elongate appearance. The vertex extends backwards on each side of the epicranial stem for a distance equal to the length of the epicranial stem. The latter has a length greater than half that of the front, the epicranial index averaging 1.88. The adfrontal suture is undulating and extends back to the vertical triangle. The sides of the latter, formed by the vertex, are almost straight, and the angle between them is slightly obtuse.

The prothoracic shield practically covers the dorsum of the prothorax, being very dark brown and often practically black. In the median line it is divided by a lighter area, which widens behind. Laterally is a kidney-shaped depression, which is not usually lighter in colour than the remainder of the shield. Microscopic examination of this area shows that its surface is reticulated with dark lines.

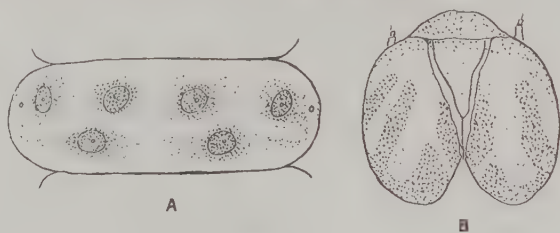


Fig. 1. Mature larva of *Platypedra scutigera*, sp. n.: A, an abdominal segment, showing distribution of pink colouration; B, head capsule, showing areas of pigmentation.

The setae are light brown, and on the body, except on the prothoracic and anal shields, they are surrounded by brown pinacula that are barely raised above the surrounding integument. Those on the prothorax are often almost black. On the dorsum and latus of the body they are well pigmented, thus giving the larva a spotted appearance. On the venter and ventrolateral region, *i.e.* surrounding setae  $\sigma$  and the  $\pi$  group, the pinacula are less prominent owing to lighter chitinisation. The pinacula on the thoracic segments are larger than those on the abdominal segments and average 0.18 mm. by 0.25 mm. On the abdomen the size averages 0.15 mm. by 0.2 mm., except the pinaculum surrounding  $\beta$  on the eight and ninth abdominal segments, which is as large as the largest on the thoracic segments.

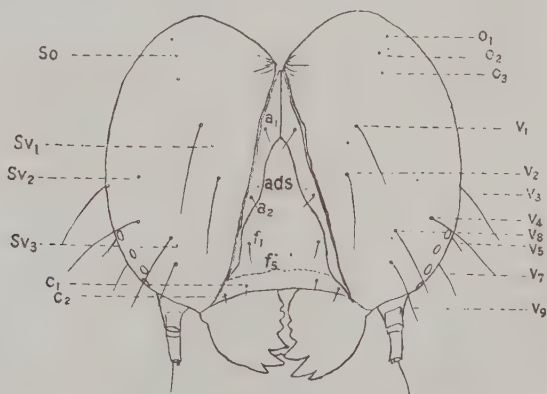


Fig. 2. Head capsule of *Platypedra scutigera*.

The larvae found feeding in green bolls are usually glassy white with the dorsum pink (colour 1c, Ridgway<sup>9</sup>), the colour being mainly localised on transversely placed patches surrounding the pinacula (fig. 1, A). Very little colour is present below the spiracles, and the thoracic segments are paler pink than the abdominal segments. The venter is white. In autumn and winter the white portions of the larvae take on a clouded appearance. The spiracles are brown, and the anal shield is prominent and dark brown. Except on the pinacula, which are smooth, the integument is beset with minute pointed subconical cornicula measuring  $5\mu$  across the base.



The true legs are white, becoming light brown on the tarsi, which bear brown claws. The bases of the legs are dark brown anteriorly, and there is a light brown plate behind. The pseudopods are white and well developed on abdominal segments 3, 4, 5, 6, and 10. The planta on a ventral pseudopod is slightly elliptical in outline and bears two curved transverse bands of crochets more closely approximated at their mesal than at their lateral extremities (fig. 3). A slight fleshy protuberance can

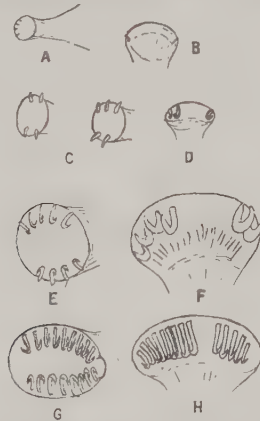


Fig. 3. Crochets on pseudopods of larvae of *Platyedra scutigera*, sp. n.: A, 1st instar, ventral pseudopod ( $\times 300$ ); B, 1st instar, anal ( $\times 300$ ); C, 2nd instar, ventral ( $\times 170$ ); D, 2nd instar, anal ( $\times 170$ ); E, 3rd instar, ventral ( $\times 200$ ); F, 3rd instar, anal ( $\times 200$ ); G, 4th instar, ventral ( $\times 140$ ); H, 4th instar, anal ( $\times 140$ ).

usually be seen in the space between the mesal extremities of the transverse bands. The crochets are uni-ordinal, but variations in size sometimes occur. The average number on each ventral pseudopod is 15; when an odd number is present, the larger number usually occurs in the anterior row; the maximum number that has been seen on a pseudopod is 22. On the anal pseudopods they are arranged as a curved transverse row in two groups, the lateral usually containing more than the mesal group, the average number on each pseudopod being 12. The crochet formula obtained by examination of a large number of larvae, is 15, 15, 16, 15, 12. The typical arrangements on two larvae is given below:—

Abdominal Segment.			Crochets.			
3	...	...	10	9	7	7
			8	8	7	6
4	...	...	9	8	7	7
			9	9	6	8
5	...	...	12	9	8	8
			8	7	6	6
6	...	...	11	8	8	7
			7	8	5	6
10	...	...	7:5	4:7	6:6	6:7

On the lateral surface of each of the anal pseudopods is a fuscous plate, and on the anterior surface is a smaller transverse light fuscous plate.

Mature larvae range from 11 mm. to 14 mm. in length.

The results obtained by calculating "Dyar's constant" and Ripley's "epicranial index" for the various instars are dealt with in later sections.

*Body Setae of the Mature Larva.*—The setal maps representing the position of the setae on the various segments are given in figs. 4, 5 and 6. The system of naming is that first adopted by Fracker,<sup>6</sup> with the exception of the several setae named  $\alpha$ ,

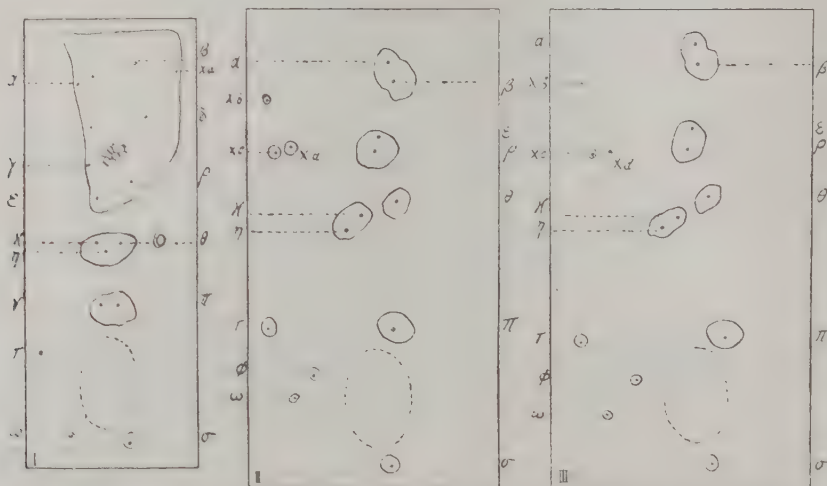


Fig. 4. Prothorax (I), mesothorax (II), and metathorax (III), of mature larva of *Platyedra scutigera*.

which were not mentioned by him, but were found by Ripley<sup>10</sup> in nearly all Noctuids that he examined. For these minute setae the original naming of Forbes, which was retained by Ripley "pending more intensive study on the question," has been adopted for the present.

One of the most striking characters of the larva is the presence of definite pinacula surrounding the bases of the setae. In many instances the pinacula are bisetose, while in the case of the prespiracular plate and the  $\pi$  group of the abdominal segments bearing ventral pseudopods they are trisetose. The  $\pi$  group of the first abdominal segment is bisetose, that of the second and seventh abdominal segments either bi- or trisetose. Small pinacula usually occur on the thorax at the bases of the setae  $\alpha$ ,  $\tau$ ,  $\phi$ ,  $\omega$ , and  $\sigma$ , but there is seldom any surrounding the seta  $\alpha$  and the seta  $\omega$  of the abdominal segments. Sometimes those surrounding the seta  $\alpha$  and the seta  $\omega$  of the abdominal segments coalesce.

It should be noted that all the setae  $\alpha$ ,  $\tau$ ,  $\phi$  and  $\omega$  of the thoracic segments have been observed in the first instar larva and must therefore be added to Fracker's list of primary setae.

It is beyond the scope of the present paper to enter into a detailed discussion on these setae, but the fact that they have often been overlooked in larvae and are certainly primary, goes to show that the anterior region of the segments has not yet received the detailed attention which other parts have.



Fig. 5. First, second and third abdominal segments of mature larva of *Platydrya scutigera*.

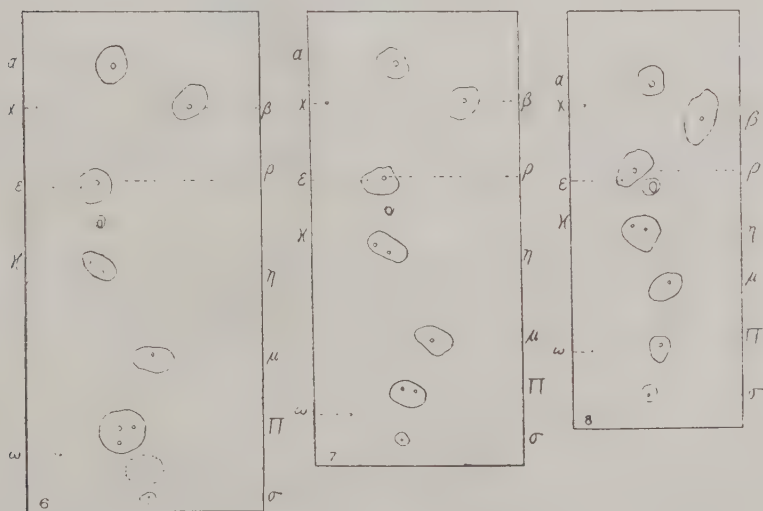


Fig. 6. Sixth, seventh and eighth abdominal segments of mature larva of *Platydrya scutigera*.

The minute size of these setae often renders them difficult to see, but Ripley has found the setae  $x$  of wide occurrence in the NOCTUIDAE. And although he has not figured  $\phi$  in *Cirphis unipuncta*, it is present nevertheless in addition to  $\tau$  and  $\omega$ . The writer has also seen all the above-mentioned setae in the mature larvae of the

Pyralid, *Conogethes punctiferalis*, Guérin. So that with their presence established in the NOCTUIDAE, PYRALIDAE and GELECHIIDAE, the way has been paved for a more intensive study in Lepidopterous larvae in general, which should yield valuable information on their homologies.

*The Pupa.*—When first formed the pupa is light brown, but later becomes dark brown. It ranges from 6.5 mm. to 9 mm. in length, usually from 7.5 mm. to 8.5 mm., and from 2 mm. to 2.75 mm. in width. It is covered with short tawny hairs. The setae are longer than the latter but are quite inconspicuous, except posteriorly. The division between the clypeus and gena is not continuous anteriorly, ceasing at the point of invagination of the anterior arms of the tentorium (fig. 7, C). The genital and anal openings are dark longitudinal slits. On the tenth segment are several



Fig. 7. *Platyedra scutigera*: A, integument of dorsum of mature larva; *p*, pinaculum; *c*, cornicula. B, tenth segment of pupa. C, antero-ventral portion of pupa; *cl*, clypeus; *g*, gena; *lb*, labrum; *m*, mandible.

setae longer and stouter than the others, and possessing enlarged ends terminating in curved hooks (fig. 7, B). There appear to be twelve of these larger setae, *viz.* a pair on each side situated laterally to the anal opening, and a group of four on each side just anterior to the cremaster, one of which is considerably shorter than the other three. The tenth segment bears also a curved cremaster directed dorsally, at the base of which on the dorsal aspect is a slight projection.

### "Dyar's Constant."

Remarkable results were obtained in the calculation of Dyar's constant or the index of growth. This is the quotient obtained by dividing the width of the head-capsule of one instar by that of the previous instar. A large number of larvae were used, and the average width of the head-capsule in each instar was obtained.

Instar.	Average Width.	Dyar's Constant.	Theoretical Width of Head.
I ... ..	0.25 mm.	—	0.25 mm.
II ... ..	0.42 mm.	1.71	0.43 mm.
III ... ..	0.75 mm.	1.78	0.74 mm.
IV ... ..	1.28 mm.	1.67	1.27 mm.

The average of these values for Dyar's constant is 1.72, which is equal to the theoretical value obtained by calculation from the widths of head-capsules of the first and fourth instars respectively.

The calculated theoretical values of the widths of the head-capsule of each instar is given above and is remarkably close to the average obtained by measurement.



### Bionomics.

The moths breed readily in captivity. Under laboratory conditions two laid 117 and 135 eggs respectively.

Practically all parts of the plant are liable to attack; squares, flowers, bolls in all stages, terminal shoots, boll pedicels, and even fairly woody stems.

First instar and second instar larvae, even in the latter part of the stadium just prior to moulting, may be found on the outside of the bolls, either making holes in the rind or sheltering under the calyx. These early-stage larvae often seem to browse on the green tissues before entering the bolls, and sometimes make several holes in a group without gaining entrance to the boll through any of them. On such occasions, small yellowish borings and frass are left near the point of attack. Cast skins and head-capsules of early stages are sometimes found adhering to the outside of bolls.

Entrance to the bolls may be effected through any point under the calyx, near the edge of the calyx, on the exposed surface, or through the apex. Cell proliferation may take place on the inner surface of the carpel where a larva has entered. The habits of larvae after entering bolls are varied. They may work round in the tissue of a carpel just below the outer surface, or in the central column, but they seem to turn their attention eventually to the seeds. When attacking the seeds they may work upwards from the first to the second seed, or they may cut through the partition and enter the adjoining lock to attack the seeds there.

Larvae of different ages, together with pupae, may occur in the same boll. Immature stages of the yellow peach moth (*Conogethes punctiferalis*) may also be found in the same boll as pink bollworms, and the early stages of these two insects may quite easily be confused by those not familiar with their distinguishing characters.

Cases have been observed of large larvae attacking cotton bolls or seed capsules of *Hibiscus tiliaceus* while not entirely hidden from view; and an instance has also been recorded of a large larva observed entering a full-sized green boll through the apex.

In the latter part of February at Gladstone infestation of large bolls of annual cotton, three months old, was over 70 per cent., and at about the same time in stand-over cotton at Sand Hills it was 90 per cent., while at the end of season 1924-25, at Callide, it was only 1 per cent. These few figures are quoted to show the high percentage of infestation on the coast where cotton was infested directly from the primary host.

Pupae are often found in cotton bolls and in the seed capsules of *H. tiliaceus*, but whether these are the usual situations selected for pupation is not known. Pupation was commonly observed in ripening bolls in March and April 1924. However, there is definite evidence that large larvae sometimes leave the scene of their attack, and also that pupation sometimes takes place between the involucre and the boll. When it takes place in the boll, a light cocoon is spun and the larva may pupate at the base of a lock, in the cracks which develop between the drying carpels, in damaged seeds, or in the lint.

At present very little can be said concerning the overwintering. It would appear from observations in the coastal districts of Central Queensland, where frosts are rare, that the insect passes the winter there as a slow-feeding larva, and at the Callide Research Farm, which is west of the first coastal range, there were indications that it hibernated as a larva. However, the possibility of overwintering being aided by adults must not be overlooked. A moth kept in the laboratory at Brisbane, and fed on a dilute solution of sugar and water, lived from 8th July to 25th August, or 48 days, which is fifteen days longer than the highest record for longevity of adults of *P. gossypiella* obtained by Willcocks.<sup>11</sup> This is an interesting and important point, since, in Queensland, after a cold change early in winter, the weather may become

quite warm and cause moths to emerge as late as July. This is what happened in 1924, and in cotton heavily infested with pink bollworms, arriving at the Rockhampton ginners in June, large numbers of larvae were pupating and moths emerging.

A *Microbracon* parasite, as yet unidentified, has been bred from this bollworm. Parasitised larvae have been observed under the calyx, just inside green bolls and in ripe bolls.

### Alternative Host Plants.

The first recorded occurrence of the larva was in *Hibiscus tiliaceus* at Southport, in April 1923, when work on the insect fauna of native Malvaceae was being undertaken. It first came under the notice of the Entomological Branch as attacking cotton bolls in the following January, although it is quite certain that in some localities it was present during the previous season.

At all places where the seed capsules of *H. tiliaceus* have been examined, the insect has been found in them, and as it occurs in them at Southport, and at Chinderah in the north of New South Wales, where no cotton is growing and where apparently it has never been grown, it appears that this *Hibiscus* is one of its primary hosts.

The larvae have also been taken from the seed-pods of *Thespesia populnea* at Palm Island, North Queensland.\*

The only other native plants on which the insect has been found are *Hibiscus divaricatus*, and the northern yellow-flowered variety of *H. heterophyllus*. It has been found only on these two plants in localities where cotton also infested with it was growing, while examination of *H. divaricatus* and the ordinary southern pink-flowered variety of *H. heterophyllus* in localities where the cotton was not infested failed to reveal its presence. It would appear then that the primary hosts were *H. tiliaceus* and *Thespesia populnea*, cotton being a secondary host, and that *H. divaricatus* and *H. heterophyllus* were subsequently attacked.

The hypothesis that the insect has spread from the two first-mentioned plants, which occur only in the coastal region, also receives support from its recorded distribution.

It seems possible that as time goes on it will be found sustaining itself on other Malvaceae that support various other cotton insects, but up to the present examination of the following plants growing in localities known to be infested with the pink bollworm has failed to reveal its presence in them: *Abutilon oxycarpum*, *A. indicum*, *Hibiscus ficulneus*, *H. irionum*, *H. vitifolius*, *Sida rhombifolia*, *Malvastrum spicatum*, and *M. tricuspidatum*.

The following plants that support certain other cotton insects, but which were not found in the pink bollworm infested areas, were also examined but gave no evidence of the insect's presence: *Abutilon tubulosum*, *Hibiscus sturtii*, *H. diversifolius*, *H. heterophyllus* (southern pink-flowered variety), and *Melhamia abyssinica* (Sterculiaceae).

### Manner of Dispersion.

There appear to have been two main methods by which the insect has become spread over a large proportion of the cotton areas of Queensland, namely, by flight, and by distribution in cotton seed; these factors have been aided by wind and certain native *Hibiscus* plants. Flight from the primary host-plants on the coast to cotton growing in the neighbourhood has been the initial step in the dispersion. This has been a comparatively simple process, as cotton fields only a couple of hundred yards

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\* Capsules collected by Mr. J. H. Simmonds of the Queensland Agricultural Department.

from the primary host were common, and in some cases the primary host was growing adjacent to the fields. The prevailing east wind would undoubtedly give assistance in the spread from field to field in coastal areas. The insect's requirements were apparently met by the cotton plant and thus it became established in it.

The larvae can live some time in the seeds and have been found in seed which has passed through the gins. Of a batch of larvae collected in the field on 2nd March, one was still alive in a seed on 20th October following 233 days later. Mr. Ballard has observed what appears to be a "double-seed" formation similar to that produced by the larvae of *P. gossypiella*.

Since the first establishment of the insect in cotton, distribution in the seed has probably been the main manner of dispersion.\*

*Hibiscus divaricatus* and *H. heterophyllus* have probably assisted in a general way in the more complete spread from field to field, and also in carrying over the insect from season to season. It seems probable that cotton at Torquay, Styx River, Bowen, Cardwell and Hick's Island, has been mainly infested directly from the primary hosts, but investigation of the matter has not been possible.

### Distribution of *Platyedra scutigera*.

As was mentioned previously, this species was first recorded from Southport. After its discovery in cotton a preliminary survey was made which revealed the fact that it was common in cotton growing in the coastal areas from Bundaberg to Marlborough just north of Rockhampton. It was also found in *Hibiscus tiliaceus* at Sand Hills and Yeppon, and in *H. divaricatus* and *H. heterophyllus* var. in some of the infested cotton areas. Further information was obtained by examination of cotton as it arrived at the ginneries. The most heavily infested areas were found to be those near the coast, particularly Sand Hills, Yeppon, The Caves and Mount Larcom.

The distribution in cotton, to June 1925, is indicated on the map accompanying this paper. The cotton areas shown represent areas in which cotton has been grown since the present revival in cotton cultivation, i.e. since 1922.†

Since the drawing of the map was undertaken, the insect has been recorded also from Hick's Island near Cape Grenville, 12°S., where the cotton was very heavily infested. This represents its northernmost record in Queensland. An examination of the map reveals a few striking features. The distribution in cotton is confined to coastal areas, its present range not extending beyond 100 miles from the coast. (Wherever cotton has been grown right on the coast it has been heavily infested.) None of the cotton growing in the southern parts of Queensland has yet been attacked. No cotton has been grown close to the coast in South Queensland.

These facts are very striking, and the most satisfactory hypothesis that can be put forward to explain them is that this insect, prior to the recent cotton revival, was sustaining itself on *Hibiscus tiliaceus* and *Thespesia populnea*, and that in those coastal localities where cotton was grown it has been found suitable to the insect and has become the primary factor in its spread further inland.

According to Mr. C. T. White, Queensland Government Botanist, *Hibiscus tiliaceus* is restricted to the coast and estuaries of rivers, and has an unbroken range on the east coast of Australia as far south as the Richmond River in New South Wales. The

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\* Mr. Ballard, in September 1925, found the Queensland pink bollworm in a cotton field in Papua. The seed for planting this field came from Queensland.

† With regard to the cotton grown near Mackay, no examination for pink bollworm has been made, so it is not known whether it is infested or not. It will probably be found to be infested.



distribution of *Thespesia* in Australia is confined to the north-east coast. Thus, the north-south range of *P. scutigera* will probably be found to be continuous and to correspond with the range of its primary hosts.

The distance from Hick's Island, in the north, to Maryborough, which represents the north-south range in cotton, is over 1,100 miles in a straight line, while the total known north-south distribution, inclusive of alternative hosts, *i.e.* from Hick's Island to Chinderah in New South Wales, is over 1,300 miles.

The present freedom of the cotton in South Queensland is to be explained by the fact that no cotton has been grown on the coast, and all cotton grown in the south has been ginned in the south, and the seed obtained has been used for redistribution to the South. Thus, it has not been allowed to become contaminated with seed from infested areas, which is ginned elsewhere.

#### *Platyedra scutigera* and *P. gossypiella* compared.

*The Larvae.*—Throughout the examination of a long series of larvae of both insects, the stronger pigmentation of the head, prothoracic shield and anal shield of *scutigera* is very evident. I have not yet had the opportunity of examining the first instar of *gossypiella*, but it would appear that a difference in the density of the pigmentation is evident even in the first larval stage; but as there is some divergence in the description of this stage by various authors, I shall await examination and comparison of the two before discussing the first instar fully. However, it would appear that if the prothoracic shield had been sufficiently prominent in *gossypiella* to be observed through the egg-shell it would have been noted by Willcocks,<sup>11</sup> who says "The thoracic shield is rather indistinct," and also "before hatching the dark head of the larva is plainly visible." In *scutigera* the prothoracic shield, as well as the head, shows up quite distinctly through the egg-shell.

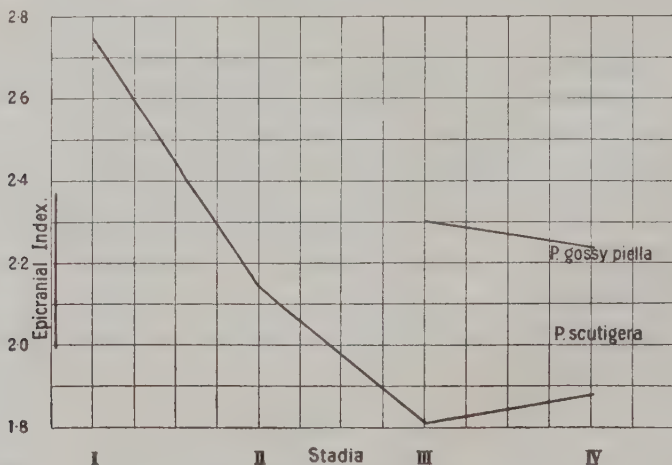


Fig. 8. Graph showing epicranial indices of four instars of larva of *Platyedra scutigera* and of the 3rd and 4th instars of *P. gossypiella*.

If the colour of these organs were the only character distinguishing the two larvae, the differences could be easily explained as being mere modifications brought about by a change of environment. Occasionally the larvae of *gossypiella* have dark heads and thoracic shields. But there are several other distinguishing features.



The head-capsule in mature larvae of *scutigera* is wider than that of *gossypiella*. For comparison, fifteen larvae of each insect were taken. The average width for *scutigera* was 1.28 mm., and that for *gossypiella* 1.17 mm. The shape of the head-capsule also differs in the two insects. When viewed from above, its outline in *gossypiella* is more nearly circular than in *scutigera*. In the latter the epicranial stem is greater than half the length of the front, whereas in the former it is less than half. In both larvae the distance from the posterior end of the epicranial stem to a line joining the dorsal hind margins of the vertex is practically equal to the length of their epicranial stems respectively. Thus there is a greater part of the vertex behind the junction of the arms of the epicranial suture in *scutigera* than in *gossypiella*. This explains the difference in shape of the head-capsules of the two larvae.

The relation between the lengths of the front and of the epicranial stem has been expressed by Ripley<sup>10</sup> as a ratio  $\frac{F}{Ep}$  called the "epicranial index." For the purpose of comparison, ten mature larvae each of *scutigera* and *gossypiella* were taken and the results tabulated and averaged. For *scutigera* the average epicranial index was 1.88, and for *gossypiella* 2.24. Fewer larvae were available for the calculation of this index in the earlier instars, but the average of the results obtained is indicated in the accompanying graph (fig. 8), which it was not possible to complete for *gossypiella* owing to lack of material.

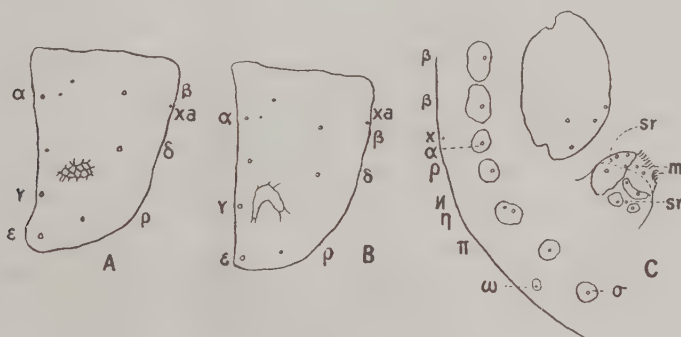


Fig. 9. Larvae of *Platydora*: A, prothoracic shield of *P. scutigera*, sp. n.; B, prothoracic shield of *P. gossypiella*, Saund.; C, setae on 9th and 10th abdominal segments of mature larva of *P. scutigera*, showing setae on lateral and cephalic aspects of anal pseudopod; m, setae of mesal aspect; sr, sensoria.

On the head-capsule of *scutigera* (fig. 2) the adfrontal setae  $a_1$ , are usually situated on each side of the epicranial stem, whereas in *gossypiella* they are more anterior, being in front of the junction of the epicranial arms. Or expressed otherwise, the setae  $a_1$  in *scutigera* are in line with the vertical setae  $v_1$ , i.e. posterior to the sensoria  $sv_1$ ; whereas in *gossypiella* they are anterior to the line  $v_1, v_1$ , and on a level with or anterior to  $sv_1$ . The adfrontal sensoria  $ads$  in *scutigera* are usually much nearer to  $a_1$  than in *gossypiella*.

On each lateral portion of the prothoracic shield of *gossypiella* is a lighter crescent-shaped area. In *scutigera* there is a slight kidney-shaped depression in almost the same position, but it is rarely lighter than the remainder of the shield. Microscopic examination shows that they differ in shape and structure (fig. 9, A, B). In *scutigera* the shape of this area (which also occurs in larvae of other families and is probably sensory) is more uniform. Ordinarily in *scutigera* its chitinisation is not less than

that of the rest of the shield, and it is composed of dark reticulated lines. In *gossypiella* the edges of the crescent are irregular, and the integument lighter than that surrounding it.

In *scutigera*, on the body, pinacula surrounding the bases of the setae are present on all segments of all instars except the first. Mature larvae of *gossypiella* often exhibit a small amount of pigmentation just surrounding the papillae bearing the setae, but only in the case of the prespiracular plate of the prothorax does this approximate to a definite pinaculum.

All the setae shown (figs. 4-6) as present on the larva of *scutigera* are represented on *gossypiella*, although  $\chi$ ,  $\tau$ ,  $\phi$  and  $\omega$  are very small, devoid of pinacula and hence difficult to see;  $\chi a$ ,  $\chi b$ ,  $\tau$ ,  $\phi$  and  $\omega$ , and  $\chi$  on the abdominal segments are not shown in Busck's figures. With regard to the position of the setae on the ninth abdominal segment in *scutigera*,  $\alpha$  is nearer to  $\rho$  than to  $\beta$ , whereas in *gossypiella*  $\alpha$  is nearer to  $\beta$  than to  $\rho$ . The difference seems to be correlated with the presence of a large pinaculum surrounding  $\beta$  in *scutigera*.

In *scutigera* the crochets on the ventral pseudopods are placed in transverse bands (fig. 3) whereas in *gossypiella* they are arranged as a penellipse with a lateral break in the series. On the anal pseudopods, in the former they are arranged in a transverse band divided into two groups, whilst in the latter the band is undivided.

It might appear from a superficial examination that the transverse bands of *scutigera* had been developed from the penellipse of *gossypiella* by some of the crochets on the mesal edge of the planta having become suppressed, and that the divided band of the anal pseudopod of *scutigera* had arisen from the undivided one by the disappearance of some of the middle crochets. But a study of the earlier instars shows that these bands have been developed from a "latero-series" (fig. 3, *a*) by some of the crochets moving on to the anterior and some on to the posterior edge of the planta (fig. 3, *c*), whilst the two groups on the anal pseudopods of *gossypiella* have been separate since the first instar, in which each group consists of a single crochet. Moreover, the average number of crochets present on *scutigera* is greater than the average on *gossypiella*. The average for fifteen mature larvae of *scutigera* was 15 crochets on each ventral pseudopod, and 11 on each anal pseudopod, whereas the average for an equal number of mature larvae of *gossypiella* was 13 and 10 respectively.

An occasional occurrence in the larvae of *gossypiella* (more particularly on the anal pseudopod of the third instar) of a crochet arrangement similar to that of *scutigera* suggests that the undivided transverse band of the anal pseudopod was preceded by the divided band and that the transverse bands of the ventral pseudopods were forerunners of the penellipse.

The integument of *scutigera* larvae is stouter than that of *gossypiella*, and the cornicula borne by the former are larger and more strongly chitinated.

*The Pupae.*—It has not been possible to examine pupae of *gossypiella* and so Busck's description<sup>4</sup> and figures of them, which have been used by most authors, must serve for the present. He indicates that the division between the clypeus and gena is distinct and continuous anteriorly to the frontoclypeal suture, whereas in *scutigera* this is not so (fig. 7, *C*).

Of the hooked setae on the tenth abdominal segments Busck says "anal opening large, slit-like, surrounded by strong hooked setae, 5 or 6 on each side; cremaster surrounded with 6 to 8 similar, strong hooked setae". In *scutigera* there are only two large hooked setae on each side of the anal opening. The others in this region, though much larger than the hairs covering the pupa, are finer and shorter than the hooked setae, taper distally and are not hooked. On the dorsal aspect of the base of the cremaster in *scutigera* is a slight projection, which apparently does not occur in *gossypiella*.

*Biology*.—Observations on the biology of the *scutigera* larvae indicate that they do not lead so secluded a life as do the larvae of the other species.

In South India *Abutilon indicum* is an alternative host plant of *gossypiella*.<sup>1</sup> In Queensland, although *A. indicum*, growing in close proximity to infested cotton, was carefully examined, no signs of *scutigera* could be found in it.

Fullaway<sup>7</sup> recorded the breeding of a single *gossypiella* from the fallen fruit of *Thespesia populnea* at the Agricultural Experiment Station at Honolulu; and to quote Busck; "Dr. Fullaway agrees that this might well have been a stray mature larva which had accidentally crawled into a cracked milo fruit for pupation." Busck examined "many hundred fruits" but could not find a single pink bollworm in them. However, *Thespesia populnea* is an alternative host of *scutigera*.

### The Economic Significance of this Information.

The theory advanced in this paper gives the most satisfactory explanation of the coastal distribution of the pink bollworm and of the present freedom of South Queensland from it, and indicates why it would have been quite impracticable to have eradicated the insect by the destruction of all infested cotton—a suggestion which was advanced just after the original announcement of the insect's occurrence, and which, if the pest had been a recent importation in seed and were still confined to a limited area, would have been well worth considering. It also gives a working basis for the maintenance of the present freedom of South Queensland from the insect.

### The Species of *Platyedra* in Australia.

In addition to the two species of *Platyedra* discussed in the foregoing pages there are at least two others present in Australia and found in various native Malvaceae in Queensland, and these are distinguishable in both larval and pupal stages. The larva of the one is uniformly scarlet (Colour 5, Ridgway<sup>9</sup>) on the dorsum. On the map accompanying this paper this insect is referred to as *Platyedra* (red larva) and localities from which it has been recorded are underlined. The other has been recorded only from Yamala near Emerald.\*

The adult of the scarlet larva has been identified by Dr. A. J. Turner as *P. gossypiella*, Saunders, and by Mr. Meyrick as "*P. gossypiella*, Saund., a slight geographical and phytophagic form." †

Dr. Turner has recorded *gossypiella* from Charleville. It seems quite probable in view of the above information that this moth was the adult of the scarlet larva.

Although both of these insects occur in cotton-growing localities, close search has failed to find them attacking the crop. In the case of the Yamala larva, the insect in the native Malvaceae was only a few yards from a cotton field. The yield from this farm was ginned separately at Rockhampton, the gins having previously been cleaned out, and no sign of the insect was found.

As will be seen from the map the scarlet larva is known to occur in localities from central to southern Queensland, and from the coast inlands. It undergoes aestivation, particularly when collected and taken indoors. One larva of a batch collected at Bribie Island on 22nd April was still alive on 20th May the following year, 394 days later. Capsules of *Hibiscus diversifolius* containing these larvae were kept in the laboratory in a glass jar covered with cheese-cloth.

\* I am indebted to Mr. J. H. Simmonds, of the Queensland Agricultural Department, for the first information regarding the presence of this insect.

† Larvae and adults forwarded by Mr. Ballard to the Director of the Imperial Bureau of Entomology. It should be noted that of the specimens submitted none were males.

The present knowledge of the host-plants of these four *Platyedra* larvae in Australia is given in the table below.\*

<i>Platyedra gossypiella</i> .		<i>Platyedra scutigera</i> .		<i>Platyedra</i> sp. (scarlet larva).		<i>Platyedra</i> sp. (Yamala larva).	
<i>Gossypium</i> sp.	W.A.	<i>Gossypium</i> sp.	Q.	<i>Hibiscus divaricatus</i> .		<i>Hibiscus sturtii</i> .	Q.
" Wild Cotton "	N.T.	<i>Hibiscus tiliaceus</i> .	Q.,		Q.	<i>Abutilon tubulosum</i> .	
<i>Hibiscus esculentus</i> .		N.S.W.		<i>H. heterophyllus</i>	Q.		Q.
	N.T.	<i>H. divaricatus</i> .	Q.	<i>H. diversifolius</i> .	Q.		
<i>H. drummondii</i> .	W.A.	<i>H. heterophyllus</i> (var.		<i>H. splendens</i> .	Q.		
<i>H. panduriformis</i> .		yellow flower).	Q.				
	W.A.	<i>Thespesia populnea</i> .					
<i>Abutilon octocarpum</i> .			Q.				
	W.A.						
<i>A. amplum</i> .	W.A.						
<i>Sida virgata</i> .	W.A.						
<i>S. echinocarpa</i> .	W.A.						
<i>S. corrugata</i> .	W.A.						
<i>Eugenia australis</i> .							
	W.A.						

Q.=Queensland. N.S.W.=New South Wales. N.T.=Northern Territory.  
W.A.=West Australia.

The presence in Queensland of three *Platyedras* which have definite larval and pupal characters by which they can readily be distinguished from each other and from *gossypiella*, and moreover which differ biologically also, should be of interest to students of the geographical distribution of Microlepidoptera, and gives support to the theory here advanced, that the Queensland pink bollworm is an indigenous insect.

### Acknowledgments.

I desire to acknowledge my indebtedness and express my thanks to Professor T. Harvey Johnston, of Adelaide University, for the loan of literature and for valuable criticism and suggestions when reading the manuscript; to Mr. E. Ballard for specimens of pink bollworms from Egypt and India and for the loan of literature; to Mr. C. T. White, who identified all the Queensland plants mentioned; and to my brother, Mr. F. T. Holdaway, for the execution of the map accompanying this paper.

### Summary.

The name *Platyedra scutigera* is proposed for a cotton insect of Queensland, previously reported as *P. gossypiella*. Its larval and pupal stages are described and notes on its bionomics and distribution are given.

There are at least four distinct species of *Platyedra* in Australia, *P. gossypiella* in West Australia and the Northern Territory, the other three in Queensland, one of which is the cotton pest, *P. scutigera*, the remaining two feeding on native Malvaceae.

\* The information on the host-plants of *P. gossypiella* in West Australia has been supplied by Mr. L. J. Newman, Government Entomologist of that State.



## References.

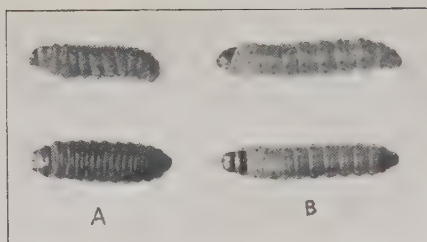
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## ADDENDUM.

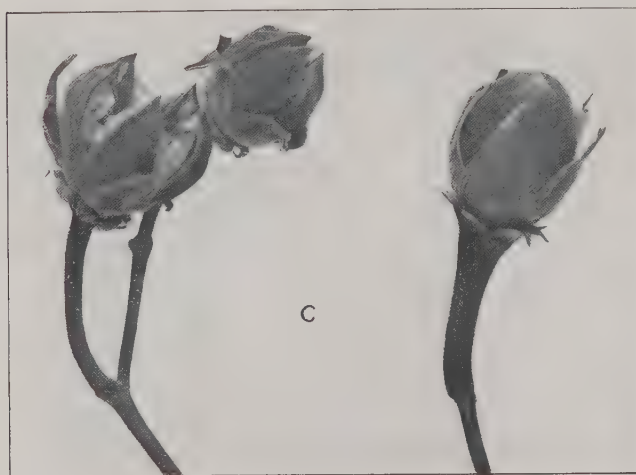
Since this paper was forwarded for publication the "Proceedings of the Pan-Pacific Science Congress (Australia), 1923," published in 1926, have come to hand. A paper by Henry Tryon, late Government Entomologist of Queensland, entitled "The Genus *Platyedra* (Cotton Pink Bollworm Genus) in Australia" (pp. 353-361) sets out the information available on the genus *Platyedra* in Australia up till that time, September 1923.

In this paper Mr. Tryon more than once expresses doubt as to the identity of the *Platyedras* in Queensland with *P. gossypiella*.





Larvæ of (A) *Platyedra* sp. (scarlet larva), (B) *P. scutigera*, sp.n.;  $\times 2$ .



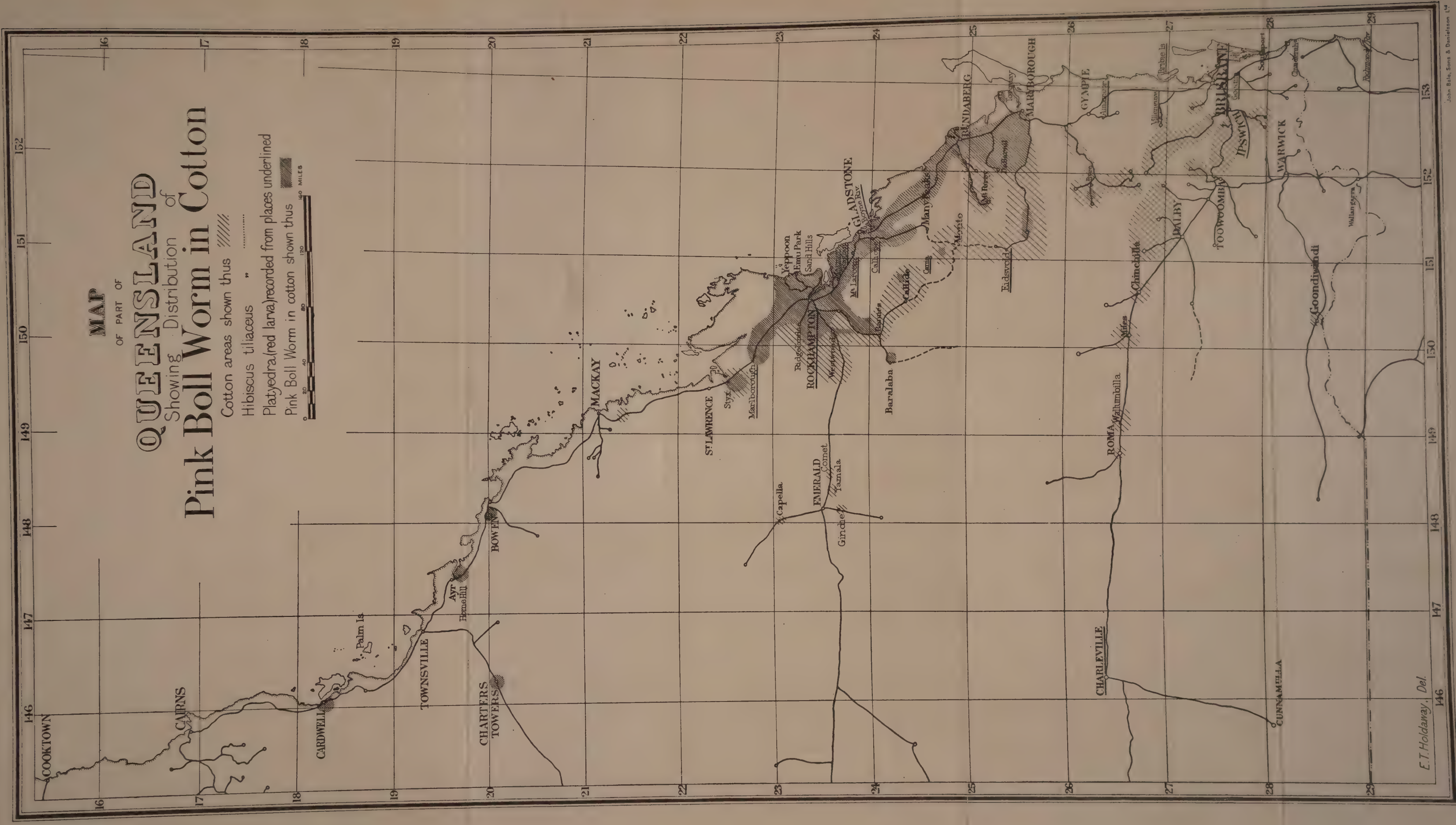
Seed capsules of *Hibiscus tiliaceus* (natural size).



*Hibiscus tiliaceus*.









*PSEUDOCOCCUS COMSTOCKI*, Kuw., AS AN ENEMY OF THE BANANA  
(*MUSA CAVENDISHII*).

By R. STEWART MACDOUGALL, M.A., D.Sc., F.R.S.E.

(PLATES VII-XIII.)

During a visit to the Canary Islands in the early autumn of 1924, the chief purpose of which was an inspection of the banana plantations for insect and allied pests, four enemies were found, each of which was the cause of some loss. Two of these had relatively small importance, *viz.* a red spider (*Tetranychus*) and a thrips. The red spider was known locally as the "red bug," the popular name being "aranillos" (the little spiders); the mites were found on the fruits, which showed the paleness and discolouration that characterise plant tissue wounded by the red spider mouth-parts. The thrips, known locally as "black bug," also caused a paleness and discolouration of the attacked fruit. Both of these enemies were known to the Spanish workers as "bicho blanco" (the animal which causes a whiteness). The other two enemies were much more serious, one of them a moth, the banana miner, *Hieroxestis subcervinella*, Walk., the subject of another paper; the second a scale-insect, *Pseudococcus comstocki*, the subject of this paper.

The cultivation of the banana is the most important industry of the Canary Islands, and the banana fruit is the chief export. The species cultivated is *Musa cavendishii*, the Chinese or Canary banana, as distinct from *Musa sapientum* of Jamaica, the West Indies and Central America.

My observations of *P. comstocki* on *Musa cavendishii* relate to the islands of Tenerife, Grand Canary, and Gomera. I did not land at Gomera, but had considerable opportunity of handling bunches of fruit collected there and sent to Tenerife for export. The scale-insect was not equally common in the different places visited; in some places it was scarce. The worst affected area was in a district known as Hoya Grande at one end of the island of Tenerife, where it was giving much trouble. *Pseudococcus comstocki* was first described in 1902, under the name *Dactylopius comstocki*, by Kuwana<sup>1</sup>, who found the insect at Akabane, Japan, in cracks and crevices of the trunk of a mulberry. Since Kuwana's record, there have been sporadic notices of the insect in the literature, with an increasing appreciation of its economic importance. Our species, then, is potentially one which, introduced into countries whose climate suits it, may develop into an extremely troublesome enemy.

### Distribution.

Besides Japan, China is one of its native habitats. It has been carried, in commerce, on its food-plants to the United States, where it is known now from New Jersey and New York to Florida. It is found in California, where it has also been intercepted several times on imported plants. Similarly it has been on various occasions intercepted at Honolulu. It has invaded New Zealand, where it has proved injurious to apples and pears. Green recorded it in England in 1921, found on bananas from the West Indies. In 1924 I recorded *P. comstocki* on bananas, imported from the Canary Islands, in Edinburgh and in East Lothian; while in 1925 I found it, under glass, in the Royal Botanic Garden on three different plants, melon, *Pittosporum crassifolium* and *Aristolochia gigas*. My Scottish records are all guaranteed by Mr. Ernest Green, for whose interest and kindness I am greatly obliged. As with so many other scale-insects, *P. comstocki* has a large number of host-plants of widely varying species and habit: trees both forest and decorative, fruit trees and plants, and plants cultivated for their flowers.



### Description of *Pseudococcus comstocki*.

This insect is one of the group of mealy-bugs, so-called from the fine mealy or granular wax which, given out by wax-pores, forms a more or less dense covering to the body (Pl. viii). The mature female varies considerably in size; it may reach a length of 5 mm. The body is oval in shape and purplish or reddish-brown in colour masked by the white waxy meal-like secretion; the antennae are 8-jointed; the mouth apparatus is well marked and the mouth bristles are long. Down each side of the body is a series of waxy appendages or tassels, at equal distances from one another; these are shortest in front, becoming longer as one passes backwards, the hindmost ones being the longest. The cleared insect (pl. ix.), with the wax-dissolved away, shows, under the microscope, 17 pairs of ceriferous tracts corresponding in position to the waxy side-tassels; these tracts show groups of pores and conical spines; in the front groups the spines are 3 or 4 in number but in the others only 2; the spines in the last tract are distinctly larger than the others. These hindmost or anal ceriferous tracts are borne by a chitinised area, oval in shape but narrowed behind and ending in slender setae. Setae are found at the sides of the body and here and there over the back along with triangular pores. There are 6 setae round the anal ring.

Ferris<sup>2</sup> has stressed the importance of the ceriferous tracts in these scale-insects for differentiating genera and species; Hough<sup>3</sup>, however, taking *P. comstocki* and its near ally *P. maritimus*, shows how there can be considerable variation, quite independent of age.

Green<sup>4</sup> in his synopsis of Ceylon species of *Pseudococcus* separates out *comstocki* from its nearest allies by the absence of dilation of the hind tibiae and the presence of translucent pores, these being scattered and not crowded (the very nearly allied *P. maritimus* has the hind tibiae dilated and the translucent pores are crowded).

The female *Pseudococcus comstocki* has the typical three immature stages antecedent to the adult stage, and the usual three moults. In all the stages a pair of eyes, the antennae, and the 6 legs, are present.

In all stages of the female there is more or less resemblance, apart from the progressive increase in size. The main differences, tabulated by Hough<sup>5</sup>, are, the absence in the first stage female of the lateral wax tassels, only the caudal pair being present; in the other stages all the 17 pairs are present; further in stages 1 and 2 the antennae are 6-jointed, in stage 3 they are 7-jointed and in the mature female 8-jointed.

The male *P. comstocki* has the typical four immature stages followed by the adult winged stage; there are four moults. In the first two immature stages the male is indistinguishable from the female. The external differences between the sexes begin to show in the 3rd immature or pre-pupal stage; they become still more marked in the 4th or pupal stage (the so-called pre-pupal and pupal stages are under cover of a white "cocoon"—Pl. vii, fig. 3). The adult male measures in length 1 mm.; body and legs reddish brown or purplish; antennae 10-jointed; three pairs of eyes; 2 flying wings; 6 legs; 2 long tail filaments.

### Life-history.

The length of the life-cycle and the number of generations possible in a year depend on the habitat, the temperature, and whether a resting or winter period intervenes. In North Virginia, with a winter season, Hough<sup>5</sup> found three generations in a year, the winter being passed in the egg-stage, and there was no overlapping of generations. In the Canary Islands, on the other hand, with a climate that is genial all the year round, multiplication is likely to be more rapid, and that there is overlapping of generations in the more favourable environment seems indicated by my finding in the Canary Islands and in the heated glass-houses of the Royal Botanic Garden, Edinburgh, all stages of *P. comstocki* at one and the same time from newly-hatched forms to males in their cocoons, and to adult females busily ovipositing in their



cotton ovisacs (Pl. x, fig. 1). Under glass at the Royal Botanic Garden on 5th January I found *P. comstocki*, on *Aristolochia gigas*, in the following stages: females, some of which were young and crawling about, others with ovisacs of various sizes holding eggs; also "cocoons" which had given up their males and other cocoons which, on dissection, still held live males ready to issue. On 6th March on *Pittosporum crassifolium* I found cocoons with males, also females and ovisacs. Plants examined in the Hoya Grande plantations, in middle September, and pieces examined indoors, and other material placed in preservative and examined in Edinburgh yielded eggs, newly-hatched young, middle-sized or half-grown individuals, males, gravid females spinning their ovisacs, and completed ovisacs. Counts made of the eggs in three separate ovisacs gave numbers varying from 120 to 130.

*P. comstocki* was found on all of the above-ground parts of the banana plant; it was present on the fruits, well down in the fruit and partly hidden in the bunch, and on the axis bearing the bunches of fruit (I have taken the scale alive in Scotland in this position); on the green blades, not only on the surface but far more abundantly in the grooved or gutter-like part of the blade on each side of the main central rib; on the lower surface in great numbers, on each side of the swollen mid-rib, where the blade, curving round slightly, gives excellent shade and protection to the insects. Specially unfortunate is the fact that great colonies of the scale have as a favourite place for their existence the inner sides of the leaf-sheaths. The true stem of the banana is the underground tuberous portion or corm. The so-called stem that stands up in the air is not a true stem but consists of concentric layers of leaf-bases, viz. the lower sheathing portions of the green leaves, which, wrapped round one another, not only act as a supporting column but also serve to protect the enclosed younger leaves and flowering shoot. In examination in the plantations I pulled back many such leaf-sheaths and found the inner sides to be the favoured position for colonies of the *Pseudococcus*. This is unfortunate, as in this position the scale-insects receive almost complete protection from treatment directed against them. Only on the roots and the true underground stem did one fail to find the scales.

### How the Scales injure the Banana.

The draining away of the sap by the feeding of hundreds of scales results in decreased output. Still, so far as the leaves go, the banana with its wealth of leafage and its powerful growth is not so sensitive to scale attack as many other plants. Leaves are the principal assimilating structures, and the great bulk of the banana plant is leaf, and quite an extraordinary amount of food reserve is produced by the plant in proportion to the area occupied. The roots and the underground stem are not attacked by the scale. Badly infested leaves suffer to some extent and poorer fruit bunches are the result. This type of damage, however, was not very great in the plantations, as there is constant treatment directed against the scale-insect. Particularly troublesome is the attack of *P. comstocki* on the fruit bunches. The scale-insects invade the axis which bears the bunches of fruit, and from here—where they are comparatively sheltered—they pass to the fruits. Beginning at the bottom of the bunches, the result of their work is the "going-off" of the "fingers" and a premature ripening. Again, when the bunches are ripening and later when they are collected, considerable labour is necessary to clean them, for scale-infested fruit may not be exposed for sale. All this, added to the general measures against the insect, entails considerable expenditure for labour and material.

### Control.

In the plantations children were at work destroying, with cloths, visible *Pseudococcus*. This is certainly well worth doing, as it accounts for tens of thousands of the insects and of their egg-masses. Special attention should be given to the groove



**Placeholder**

on each side of the main rib of the blade on both upper and lower surfaces. A cloth with two fingers inside, or a piece of wood, rounded at the end, inside the cloth, run down these grooves would be more effective than any spray. Care must be taken not to damage the leaf, which could be supported by one hand while the other did the work. Great numbers of the insects can also be killed just inside the leaf-sheath where the blade of the leaf spreads out from the sheath; this is a favourite place for colonies of *comstocki*. The absence of a resting dormant season for the banana in the Canary Islands renders impossible the use of certain winter-washes, and others which would destroy the eggs. Proprietary washes known as Clensel and Cyllin were in use against the scale, the fruit bunches receiving individual treatment. Paraffin emulsion was also employed. The insect has a waxy covering and is often in dense numbers, and regard must be had to the reaching of the insects' body by the contact spray. A high percentage of "kill" is also necessary to compete against the great power of multiplication of *P. comstocki* in the favouring climate.

In Egypt, where in some places sugar-growing is more than threatened by an allied scale-insect, great benefit has resulted from dipping the new "sets," before planting, in paraffin emulsion. Where a new banana plantation is being established with tubers or suckers from another area, such tubers might be disinfected with paraffin emulsion previous to planting.

As regards fumigation, either in the case of establishing a new plantation, or of the old tuberous stem and the sucker in association with it from which the new "stem" and fruit will be derived, or against the mass of *Pseudococcus* sheltered under cover of the leaf-sheaths of the growing plant and not reachable by any spray, there is room for experimental work, and some is being done. Bisulphide of carbon has been suggested in special cases, but it would, even if practicable, be too expensive on a wide scale; and information which may result in experiment has been given regarding dusting with calcium cyanide. In any case the leaf-sheaths and the old leaves present on the plantation make the problem of fighting *Pseudococcus* a very difficult one. If these could be removed or destroyed the problem would be much easier of solution, but the culture conditions seem to make this impossible.

Search was made for natural enemies, predators or parasitic insects, but none was found, owing, I think, to the presence and activity of the Argentine ant (*Iridomyrmex humilis* Mayr), an ant with a very sinister reputation as an enemy of man directly and indirectly. The Argentine ant does not injure the banana plant but lives in association with the scale-insect and patrols the bananas so that the *Pseudococcus* is kept free from predacious and parasitic insects. The share of *Pseudococcus* in the partnership is to supply nourishment and refreshment to the ant, in the form of excreted sweet stuff and perhaps wax. I have watched the ants, under the lens, scraping the *Pseudococcus* female almost free of the mealy wax, so that the normal purplish or reddish brown colour of the scale-insect showed up quite clearly.

These Argentine ants abounded in the plantations at Hoya Grande and were in constant patrol on the scale-infested bananas. On pulling apart the leaf-sheaths little heaps of soil at their bases held ants and eggs. On examining the soil and disturbing the surface layers the ants were found in thousands. This ant cannot sting, and its bite is not severe. So far as I know this is the first record of the Argentine ant from the Canary Islands. The native home of the ant is the Argentine and Brazil, but as a result of commerce it has reached the United States, South Europe, South Africa, Madeira and now the Canary Islands. The presence of the Argentine ant in such numbers makes almost impossible the successful introduction from elsewhere of insects that prey on and parasitise the *Pseudococcus*. It is true that there are encouraging accounts from the United States of success in destroying this ant by means of poisoned honey and sugar, but the problem is complicated in the Canary Islands by the fact that the ant is also an indoor household enemy. It is omnivorous in diet, and its presence in houses has become a nuisance; almost

anywhere on laying on the floor or ground a piece of food one found this covered by Argentine ants in a short time. The determination of these ants as *Iridomyrmex humilis* is guaranteed by Mr. H. St. J. K. Donisthorpe, to whom my thanks are due.

### An Entomogenous Fungus.

On several of the leaf-sheaths, near their base, a fungus was found. The eye was attracted to it by a yellowish-brown-green discolouration. The mycelium of the fungus in many cases quite covered the mealy *Pseudococcus*, and spores were produced in abundance (Pl. x, fig. 2). Through the kindness of the authorities at Kew the species has been determined as quite near to *Aspergillus perniciosus*.

Tentative experiments with this fungus against *Pseudococcus comstocki* on *Aristolochia gigas*, in a heated house at the Royal Botanic Garden, Edinburgh, have not encouraged one to believe that the fungus will prove, in nature, of much service as an enemy of the scale-insect.

### Other Scale-insects on Banana.

On banana plants either in the Botanic Garden, near Puerta Cruz, or in the garden of the Director, four species were found, viz.:—

*Aspidiotus cyanophylli*, Sign, common on the old leaf sheaths (Pl. xi).

*Aspidiotus hederæ*, Vall., on banana fruit (Pl. xii, fig. 2).

*Ceroplastes actiniformis*, Green, an Indian insect which has spread to the Canary Islands (Pl. xii, fig. 1).

*Lecanium nigrum*, Nietn., cosmopolitan and with many hosts (Pl. xiii, fig. 2).

*Diaspis boisduvali*, Sign., also found on palms and many other monocotyledons (Pl. xiii, fig. 1).

From Hoya Grande, on a piece of leaf-sheath badly infested with *P. comstocki*, *Aspidiotus lataniae*, Sign.

### Scale-insects other than those on Banana.

No attempt was made to form a collection of scale-insects, but the following species were found and are named here for record.

*Dactylopius coccus*, Costa (*Coccus cacti*, Linn.). This is the well-known cochineal insect; it was everywhere in Tenerife and Grand Canary on its host plant, *Nopalea coccinifera*. The cochineal industry was, before the discovery of aniline dyes, the chief industry in the Canary Islands. Though sadly fallen from its former glory, it is still practised, e.g., in the island of Grand Canary, where I saw the insects being brushed off the *Nopalea* and collected for dye purposes. In middle September the males were abundant; some of the native collectors described them to me as mites and regarded them as a sign of disease.

*Lecanium nigrum*, Nietn., on *Anona macrocarpa*.

*Lecanium oleæ*, Bernard, on *Nerium oleander*.

*Prototulvinnaria pyriformis*, Ckll., on *Hedera* and *Laurus*, on the latter of which it was very troublesome. This is a West Indian species which has wandered far afield.

*Diaspis rosæ*, Bouché, on *Rosa*.

*Lecanium hemisphaericum*, Targ., and *Diaspis zamiae*, Morgan, both on *Cycas revoluta*.

*Pseudococcus citri*, Risso, on grape vine.



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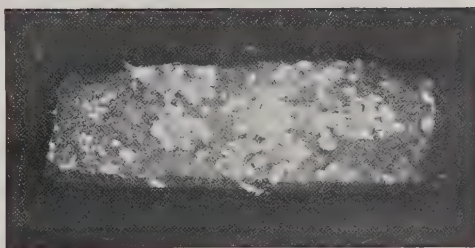


Fig. 1. *Pseudococcus comstocki*, natural size.



Fig. 2. *P. comstocki* on banana leaf.  $\times 4$ .

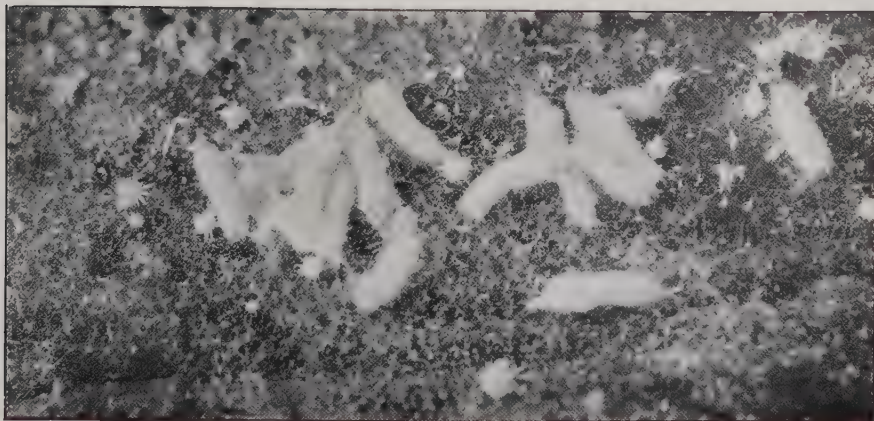


Fig. 3. *P. comstocki*, male puparia.  $\times 8$ .



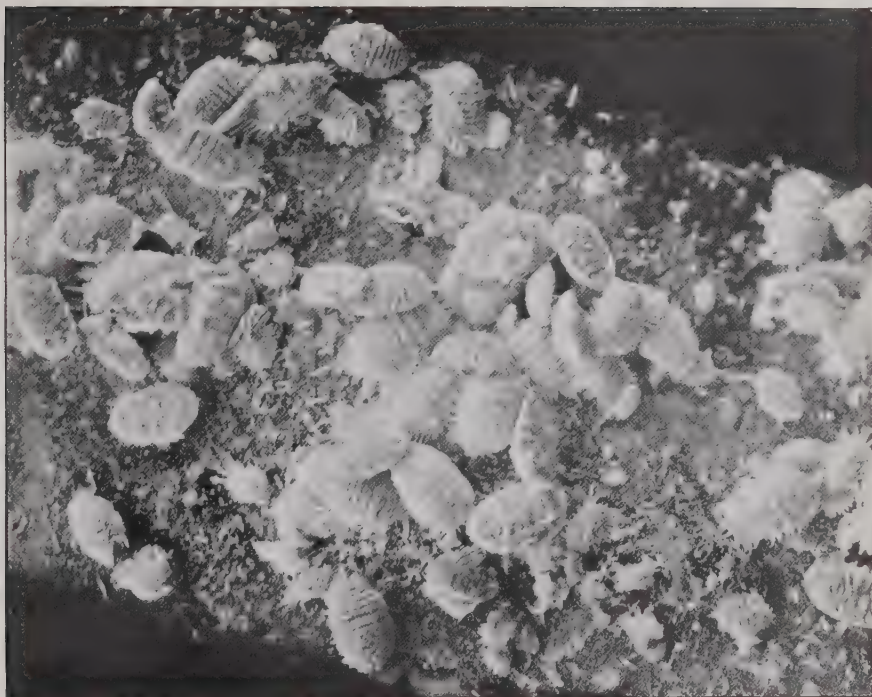


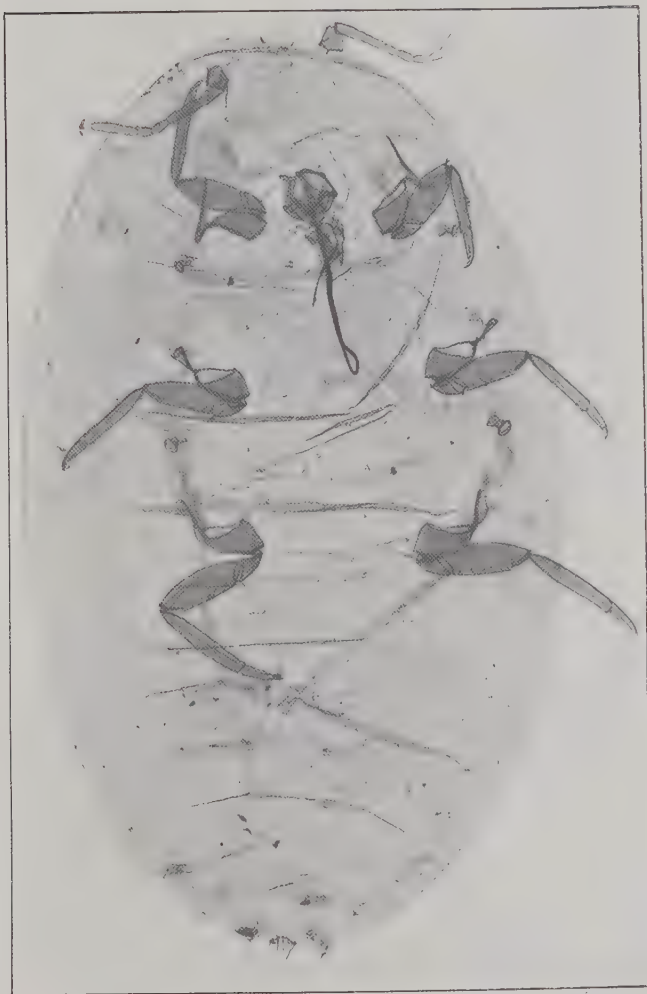
Fig. 1. *Pseudococcus comstocki*.  $\times 8$ .



Fig. 2. *Pseudococcus comstocki*.  $\times 80$ .







*Pseudococcus comstocki*.  $\times 172$ .



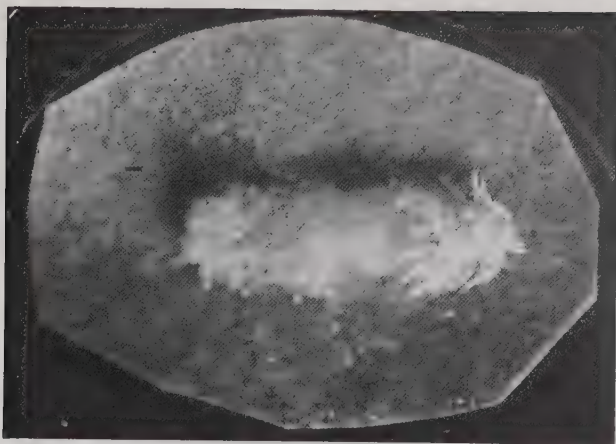


Fig. 1. *Pseudococcus comstocki* and ovisac.  $\times 7$ .

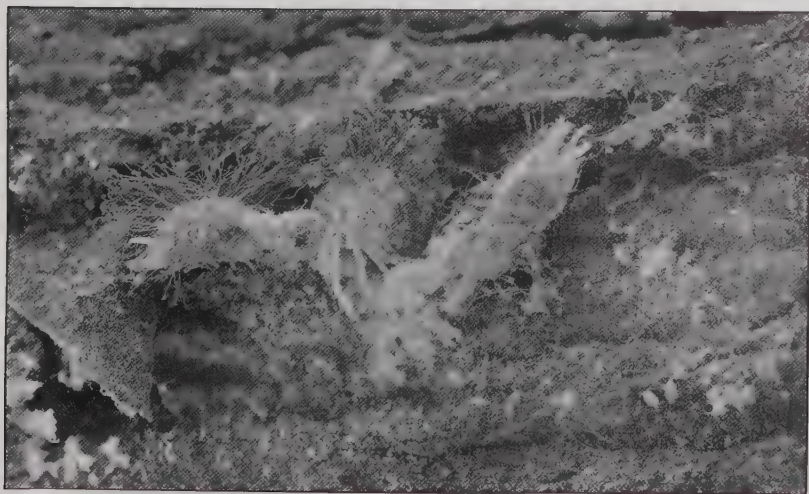


Fig. 2. *P. comstocki* attacked by a fungus, *Aspergillus* sp.  $\times 8$ .





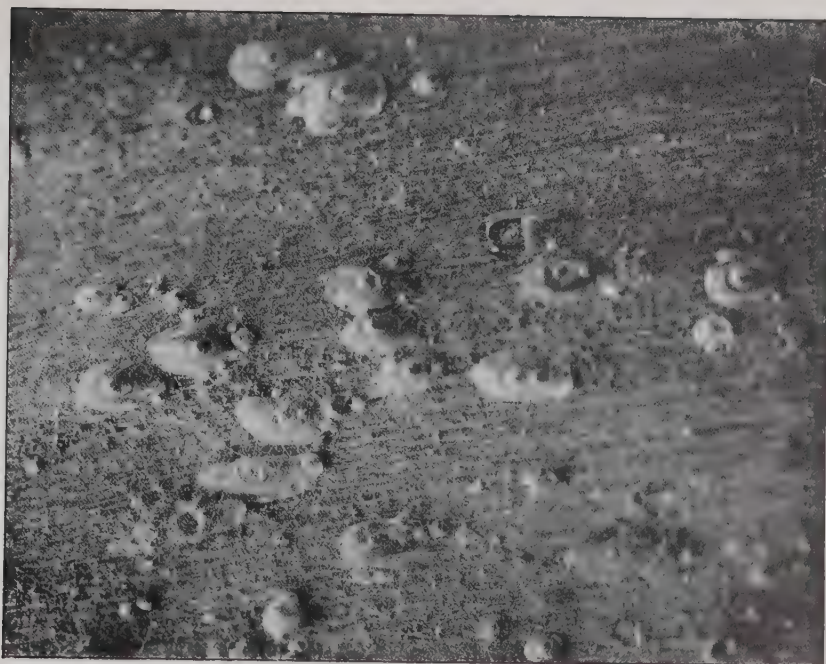


Fig. 1. *Aspidiotus cyanophylli* on banana leaf-sheath.  $\times 8$ .

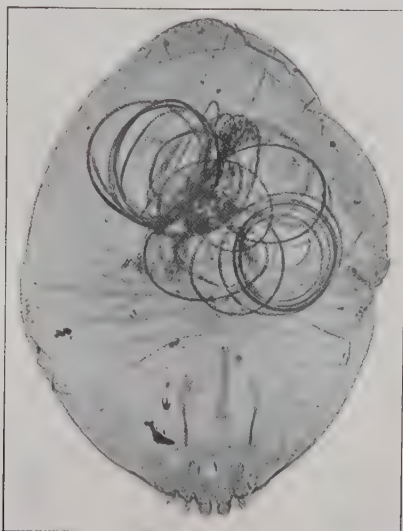


Fig. 2. *Aspidiotus cyanophylli*, mature ♀.  $\times 172$ .



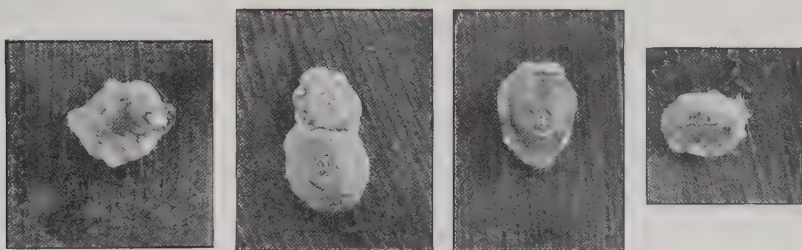


Fig. 1. *Ceroplastes actiniformis* on banana leaf-stalk.  $\times 4$ .

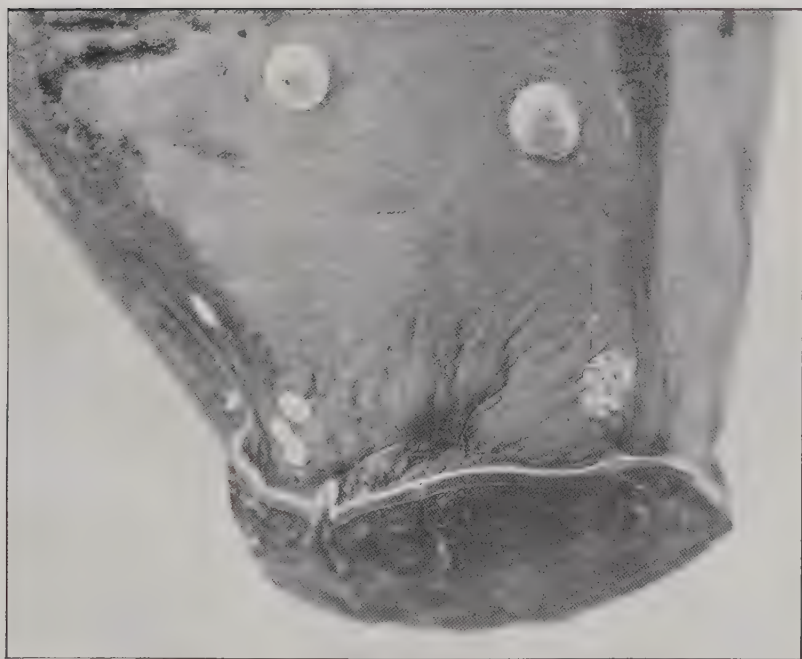


Fig. 2. *Aspidiotus hederæ* on banana fruit.  $\times 4$





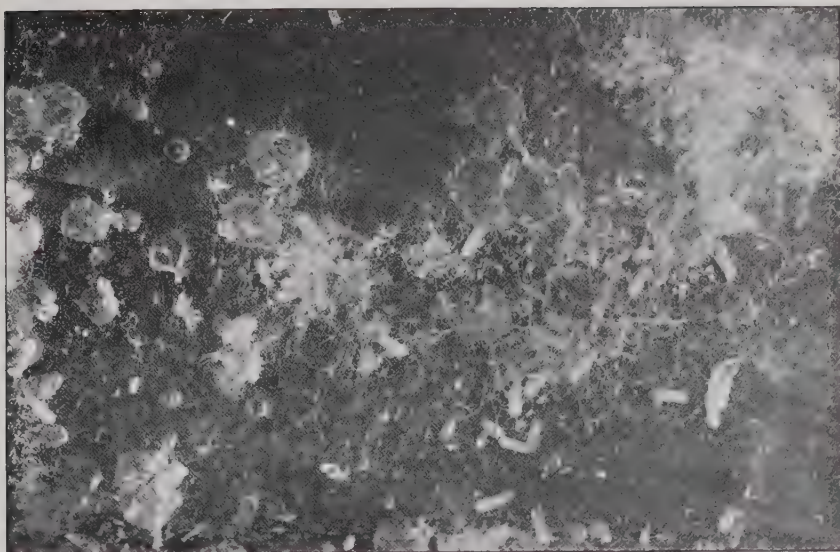


Fig. 1. *Diaspis boisduvali*, male and female scales, on leaf-sheath of banana.  $\times 4$ .

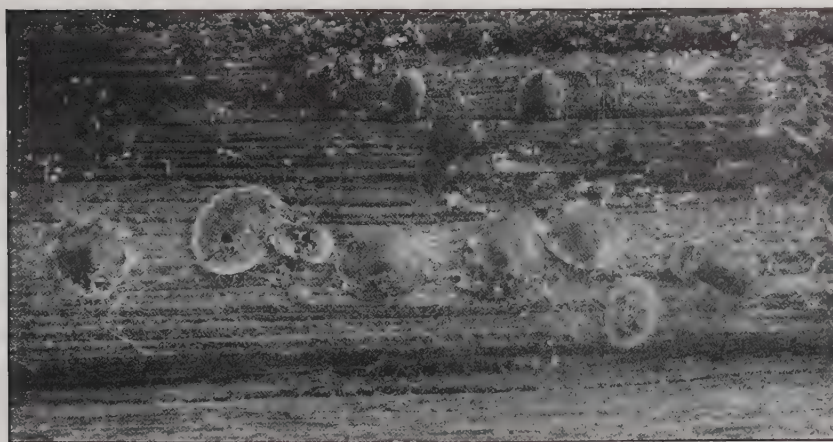


Fig. 2. *Lecanium nigrum* on banana.  $\times 4$ .



## THE BRACONID GENUS *APHRASSTOBRACON*, ASHM.

By T. V. RAMAKRISHNA AIYAR,  
Madras Agricultural Department.

The genus *Aphrastobracon* was erected by Ashmead in 1895\* to include an interesting new Braconid that was bred out from the lac insect, *Tachardia albizziae*, Gr., by Mr. E. E. Green, in Ceylon, and the species was named *A. flavipennis*. Since then we have no further records of this insect from Ceylon or elsewhere. Even Mr. Green does not refer to it in connection with the same lac insect in his recent last volume on the COCCIDAE of Ceylon, though he has made mention of another Braconid, *Bracon greeni*, Ashm., bred by him from the same host and described by Ashmead as the same time as *A. flavipennis*. However, this insect was noted by the writer of this paper some years ago in South India, and latterly during the course of his studies on the local COCCIDAE specimens of this species were reared from two or three common scale-insects. It was at first thought to be a parasite on the scales and was identified by a well-known authority as a species of *Megalommum*, Sz.; a record to this effect may be found in the author's "List of Parasitic Hymenoptera of Economic Importance from South India" † published in 1921. Further studies and observations made on the bionomics of this insect in recent years revealed its true habit as a parasite, not on the scale, but on a Lepidopterous caterpillar feeding on the scale, and its correct identification was obtained after consulting two or three specialists. A brief reference to the insect, explaining its habits, is made in the author's recently published memoir‡ on the nim mealy scale, *Pulvinaria maxima*, Gr.

The taxonomic, biological and economic aspects of this insect present some very interesting features, and as such it may not be out of place to put on record some of the recent notes and observations made on this parasite which might supplement the brief and incomplete information on it published over twenty years ago.

### Systematic Position and Affinities of the Genus.

*Aphrastobracon* is a member of the subfamily VIFIINAE, till recently known as BRACONINAE§ as definitely characterised by Gahan, Muesebeck, etc. It has the head cyclostomatous, occiput immargined, the posterior wings with very small submedian cell, and the front wings with three cubital cells, of which the first cubital is always separated from the first discoidal, and the subdiscoidal nervure always rising below the middle of the discoideus. When he first described the insect Ashmead gave it only generic rank, but later on (Proc. U. S. Nat. Mus. xxiii, 1900, p. 136) he raised it to the rank of a tribe, APHRASSTOBRACONINI, on the following grounds.

Submedian cell much shorter than the median; eyes large, extending clear to the base of the mandibles, malar space wanting APHRASSTOBRACONINI.

Submedian and median cells equal; eyes not extending to base of mandibles. BRACONINI.

Again in 1904 Szepligeti (General Insectorum: Braconidae, p. 136) raised the status of this insect by creating a special subfamily for it under the name of APHRASSTOBRACONINAE, practically for the same reason as Ashmead, viz., the antefurcal nature of the nervulus, and the consequent shortness of the submedian cell in the

\* Proc. U.S. Nat. Mus. xviii, 1895, p. 646.

† Proc. 4th Ent. Meeting Pusa, 1921, p. 365.

‡ Mem. Dept. Agric. India, Entom. Ser. viii, no. 12, April 1925, pp. 127-155.

§ The old name BRACONINAE was altered to VIFIINAE by Gahan (Proc. U.S. Nat. Mus. liii, 1917), and this has been accepted by recent workers.



fore wing. With all due respect to these eminent authorities it is felt that there is not sufficient justification to give this insect more than generic rank under the subfamily VIFIINAE. Ashmead himself made a statement at the end of his original description of the genus that may be quoted with advantage in this connection. "At present I prefer to place this genus in the subfamily Braconinae, since I am inclined to believe that too much importance has been given to the length of the basal cells." This view appears quite right, since a good deal of variation has been noted in comparative lengths of the median and submedian cells of the fore wing in a series of specimens examined by the writer. In some, there is hardly any difference in their lengths and in others the difference is very slight and practically negligible. This variation in the length of the submedian cell appears to be caused by the frequent variation in the shape of the second discoidal cell, and the consequent change in the contour of the transverse median nervure (nervulus). Speaking of this feature in the wing venation, it is very surprising to note that so eminent a Hymenopterologist as Ashmead has overlooked some of the more striking features in the wing venation of this insect, viz., the peculiar roundish or oval shape of the second discoidal, the thickening of the veins around it, and the characteristic curvature of the basal, cubital and radial veins.

The presence of these wing characters, together with the possession of large and emarginate eyes, and the basal area on the 2nd abdominal segment, brings *Aphrastobracon* very close to two other genera described after it in the subfamily VIFIINAE viz., the Australian *Megalommum* of Szepligeti,\* and the African *Curriea*, of Ashmead,† and it is evidently this very close similarity in characters that made Viereck, to whom specimens were submitted in 1919, identify this insect as a *Megalommum*, as recorded in the author's Parasite list of 1921 referred to above.

A few remarks on the status of these two genera may be found useful before we reconsider the relation of *Aphrastobracon* to these very closely allied forms. Ashmead, when he erected the genus *Curriea*, did not add any clear description of it, but only indicated its salient features, and that only in a tabular synopsis of the BRACONINAE; the genus and type practically remained manuscript names until the latter was described by him four years later (Ent. News, xv, 1904, p. 18). Meanwhile Szepligeti, who was evidently unaware of this latter description of Ashmead's, suggested in his Genera Insectorum volume that *Curriea* and *Megalommum* might be congeneric, though in a later paper‡ he says that *Curriea* is distinguished from *Megalommum* by the crenulated 2nd suture on the abdomen. Viereck in his volumes§ on the "Type species of Ichneumon flies" also presumes that these two genera may be one and the same. Entertaining some doubts as to the real identity and affinities of the South Indian insect determined by Viereck as *Megalommum*, the author approached Prof. C. F. Baker of the Philippines, the Director of the Imperial Bureau of Entomology, London, Mr. C. A. Rohwer of the United States National Museum, and Dr. L. Biró of the Hungarian National Museum, for their views, and the insect was identified as *A. flavipennis*, Ashm., by all of them, and the writer hereby expresses his sincere thanks to all the above authorities for the ready help and valuable opinions on this subject. Mr. Rohwer also suggested that *Megalommum* and *Curriea* may be same, and that both of them appear very closely allied to *Aphrastobracon*. Though the writer has not seen *Curriea*, owing to the kindness of Dr. Biró he has been able to secure a specimen of *Megalommum biroi*, Sz., and a comparison of the characters of this specimen with the description of *Curriea*, coupled with the opinion of eminent specialists like Rohwer, Viereck and Biró, leads one to conclude that these two genera should be merged into one and that *Curriea*, Ashm., should sink, giving priority to Szepligeti's *Megalommum*, the description of which appeared several months earlier.

\* Termes. Füzetek. xxiii, Feb. 1900, p. 50.

† Proc. U.S. Nat. Mus. xxiii, Oct. 1900, p. 137.

‡ Ann. Mus. Nat. Hung. iv, 1906, p. 549.

§ U.S. Nat. Mus. Bull. no. 83, 1914, pp. 39 and 90.

Now returning to *Aphrastobracon*, it is found that there are numerous structural features common to this and *Megalomnum*. The striking peculiarities in the wing venuration, the large eyes with their inner emargination, and the presence of a basal area on the second abdominal segment, are all characters present in both. With regard to the length of the submedian cell in the forewing, which was considered to be the most important differentiating character in *Aphrastobracon*, this feature completely breaks down when we compare *Aphrastobracon* with some species of *Megalomnum*. From a few wing sketches with which the Imperial Bureau of Entomology kindly supplied the writer, it is evident that in one species of *Megalomnum* (*M. flaviceps*, Cam.) the submedian cell is distinctly shorter than the median, while in the specimen of *M. biroi* obtained by the writer from Dr. Bíró the submedian is slightly longer than the median. Thus, eliminating this character which we find to be variable, the differences between *Aphrastobracon* and *Megalomnum* appear very few. In the former the head is transverse and narrower; Rohwer says it is quadrate in *Curriea*, and it is cubical in *Megalomnum* according to Szepligeti. Even this difference, if it were really of generic significance, breaks down when we note that in a Philippine species recently described by Baker (Philip. J. Sci. xii, 1917, p. 213) as an *Aphrastobracon*, the head is not transverse, but cubical. Another difference appears to be the mode of termination of the recurrent nerve; in *Aphrastobracon* it meets the first cubital clearly before its apex, while in some species of *Megalomnum* it is interstitial with the first intercubitus and in some more or less as in *Aphrastobracon*. Thus even these two apparent differences are not constant. It is therefore not unlikely that eventually these two genera may have to be united.

### The Structural Features of *Aphrastobracon flavipennis*.

The following is Ashmead's original description of the species:—

"Male:—Length 4.5 mm. Brownish yellow, eyes black, very large, occupying the whole side of the head and leaving the face very narrow. Antennae about 48-jointed, as long as body, brown-black, the scape and pedicel beneath brownish yellow; the scape is about three times as long as thick, the pedicel very small, the first joint of flagellum longer than wide and the longest flagellar joint, the others all being a little wider than long. The head and thorax except the face, which is finely shagreened, are smooth and shining, the parapsidal furrows complete. The abdomen is oblong, the second segment with a basal triangular elevation, the first being grooved at the sides and forming a wedge-shaped plate; the third and the fourth segments are delicately sculptured. Wings large, yellowish hyaline, the costa, stigma and veins yellow. The submedian cell is shorter than the median, the recurrent nervure joins the first submarginal cell at its apical fifth, the second abscissa of radius is about two and one half times as long as the first, the second transverse cubitus being scarcely longer than the first abscissa of the radius, making the second submarginal cell very narrow."

This description was drawn up from a single male specimen. Several males and females have been reared or collected by the writer in South India, and the following are some of the structural peculiarities not noted by Ashmead.

Apart from the possession of a prominent ovipositor in the female, the differences between the sexes are very few and not very appreciable. The female is slightly larger. In the male the antennae are curved at the tip, while in the female they are not so.

The general colour is brownish rufous yellow and sometimes light yellowish. The head, except the eyes and tip of mandibles which are dark (in some specimens the eyes are bluish grey), and the wing veins are flavous yellow. Ocelli dark brown. The scape, the pedicel and the basal portion of the first joint of the flagellum flavous brown; the proximal portion of the flagellum deep brown, the distal third of a lighter reddish brown. There is a very small dark spot near each tegula on the thorax.

Tips of tarsi dark. The terebra in the female red, the sheaths dark. The face between the ocellar region and base of antennae is more or less excavated. The large eyes have a shallow emargination along the inner margin opposite the bases of the antennae, not so deep and narrow as in *Megalommum biroi*; this character, which is very striking, is only found in this genus and *Megalommum* in the whole subfamily. The posterior ocelli are larger than the anterior. There is a good deal of variation in the number of antennal joints; the writer has noted 43-51 in males and 48-49 in females. The flagellar joints are as long as broad or slightly broader than long, except the first and last which are distinctly longer; each joint shows a number of fine longitudinal pale grooves, and is fringed with very short hairs at the sides. The thorax smooth and shining, especially the mesopleurae. The mesonotum is very convex and smooth; the paraspidal grooves not deep and not clear posteriorly; the posterior boundary of mesonotum finely crenulated. Abdomen as long as head and thorax together. All the segments except the first are broader than long; the first is longer than broad, and has a distinct long groove along each side dorsally dividing the central region into a wedge-shaped area; the grooves diverge posteriorly and meet the apex of the segment; in some specimens a faint median groove is also found along the central area. The triangular space at the base of the second segment is shining and comparatively smooth and reaches the middle of the segment, its apex being thence produced backwards in the form of a short carina, which does not reach the apical margin; there is a groove along each side of the triangle distinctly crenulated with longitudinal ridges and in addition to these grooves there is a longitudinal one near each lateral margin of the segment. The suture between 2nd and 3rd distinctly crenulated and the anterior angles of 3rd segment slightly grooved. In the female the ovipositor is half as long as the abdomen. The body is clothed with very short pale white hairs, especially is this the case on the legs, scape, sides of median segment, and on the posterior abdominal segments.

The wings extend beyond the abdomen. They have the colour of the body, but the veins and stigma are bright flavous; the apical region is very faintly smoky and iridescent. With regard to the venation, the submedian cell is in some specimens slightly shorter than the median, and in others hardly less than the median in length. As stated before, this variation is due to the indefinite formation of the 2nd discoidal cell and the changing contour of the nervulus. The 2nd discoidal is found assuming different shapes; in some it is elongate oval, in some almost circular, while in others it is broadly oval, and the veins around this cell are thickened, especially at the junctions.

Length, ♀, 4-6 mm., plus terebra 1.5 mm.; ♂, 3-5.5 mm. Wing expanse, 14 mm.

This insect has been noted in different parts of South India. It has been obtained from Narasapur and Bezwada in the Northern Circars, from Mysore, and from Coimbatore in the South. There is no evidence to show that the species occurs in Northern India.

### Hosts and Host Relations.

Though in the early years, when this insect was bred out from Coccid material, it was thought to be a natural enemy of the scale itself, it was later on found that the real host of the parasite is a Noctuid caterpillar, *Eublemma scitula*, Ramb., which latter is the real enemy of the scale-insect. This Noctuid caterpillar has till now been found on the following scale-insects in South India: The lac insect (*Tachardia lacca*), found on *Pithecolobium saman*, *Zizyphus jujuba* and *Pongamia glabra* in Coimbatore, and on *Shorea talura* in Mysore; the nim mealy scale (*Pulvinaria maxima*), chiefly infesting the nim tree (*Azadirachta indica*) in and around Coimbatore; the babul scale (*Anomalococcus indicus*), on the babul (*Acacia arabica*) in and around Coimbatore; and on the guava mealy scale (*Pulvinaria psidii*), on guava, *Morinda tinctoria*, etc., in and around Coimbatore. Of these *E. scitula* is most commonly found on the babul



scale and the nim mealy scale. This caterpillar, a brief account of which is given in the author's memoir on the nim scale (*op. cit.* pp. 145-147), has the curious habit of protecting its body with a covering made of the empty shells and exuviae of the scale-insects which it has devoured, and this covering later serves as a cocoon, but when attacking lac the caterpillar burrows into the mass of lac insects and remains in tubular galleries. It is just at that period when the young caterpillar moves about with a small and comparatively thin-walled protection that the wasp parasitises it. It has not however been ascertained definitely whether the female wasp, which has a well developed ovipositor, deposits the egg by piercing the thin wall of the covering, or manages to reach the caterpillar through the narrow marginal passages. So far, only one grub has been found on a single caterpillar.

A full-grown grub measures 4.5-5 mm. The body is stout and fleshy. Head not distinctly marked off from the body. Pinkish yellow in colour with the anterior and posterior regions pale, the middle region sprinkled with whitish specks, evidently particles appearing through the transparent body surface. The younger grubs do not show the pinkish colour very clearly. Pupation takes place inside a semi-transparent, pale white, silken cocoon, inside the original covering of the *Eublemma*. The pupa (4.5 mm.) is pale shining white with a yellowish tinge. Eyes above greyish brown and large. Antennae long, extending right up to the tip of abdomen. The pupal period occupies 8 to 10 days.

### Economic Importance of the Insect.

The fact that this Braconid is a natural enemy of the Noctuid caterpillar found on some of the common and more or less destructive scale-insects renders it economically important, especially when it attacks its caterpillar host while this latter is feeding on the lac insects of commerce. So far as the writer knows, there is no definite record of this insect anywhere from North India, nor is there any mention of it in publications on lac or *Eublemma* by Stebbing, Imms or Misra. Imms & Chatterjee\* in their monograph on the lac insect refer to several parasitic Hymenoptera reared from lac, and think that the wasps *Brasema annulicaudis*, Cam., *Chalcis tachardiae*, Cam., *Bracon tachardiae*, Cam., and *Apanteles tafchardiae*, Cam., may probably be parasitic on *Eublemma*; but in not a single case have they definitely ascertained whether this is so or not. Neither in his revised Bulletin on the lac insect† nor in his recent paper on *Eublemma amabilis*‡ does Misra make any mention of this insect, though he refers to a Braconid grub noted on *Eublemma* caterpillars and speaks of its adult as resembling a *Microbracon* superficially. If it is proved that this wasp is not found in Upper India, it will certainly be worth the trouble on the part of lac farmers in Central India, Chota-Nagpur, etc., to introduce this useful insect into those tracts, especially in view of the well-known fact that lac is very seriously damaged by *Eublemma* spp. all over the lac area in Northern India. It is desirable also that the true status of the many insects that have been bred from lac insects, but about which there are very few notes so far, should also be ascertained, so that we may be in a position to know which are really useful and which injurious.

While *A. flavipennis* has been noted to be a useful insect and friend of the lac farmer, it unfortunately proves injurious when it parasitises *Eublemma* on scales that attack useful plants, such as the species of *Pulvinaria* on nim and the babul scale (*Anomalococcus*), and thus assumes quite a different rôle economically.

So far as the writer is aware, only four species of the genus *Aphrastobracon* are on record. The first is Ashmead's type of the genus *A. flavipennis* from Ceylon (1895); the second was described by Prof. C. F. Baker from the Philippines and named *A.*

\* Indian Forest Memoirs (Zoology), iii, pt. 1, 1915.

† Pusa Bulletin no. 142, 1923.

‡ Rept. 5th Ent. Meeting Pusa 1923, pp. 238-247.



*philippinensis* (1917); and the last two are *gratiosus* and *guttifer*, described from West Africa by Enderlein (1920). A fifth species has been found in South India and is described below.

### **Aphrastobracon maculipennis, sp.n. (fig. 1).**

**FEMALE.** Body and legs rufous yellow. Head, especially the vertex behind the ocellar region and cheeks, bright yellow. Antennae dark, but brownish towards end of flagellum; the scape, pedicel, and base of first flagellar joint yellowish, but with a narrow and distinct long dark streak along the outer side. Tip of mandibles, the eyes and the extreme tips of tarsi dark. Ocelli shining brownish. Wings flavo-hyaline; the costa, stigma and the proximal wing veins distinctly yellow; the costa above the first cubital cell and the hairs in that region black; a dark brown smoky patch at base of first cubital cell; this smoky brown colouring is apparent in the first and second discoidal cells also, but of a lighter tinge; in the former it is somewhat diffuse, while in the second discoidal it is a clear spot right in the middle of the cell. The whole dark marking on the wing may be regarded as a broad interrupted smoky band running across the wing from the base of the stigma to the second discoidal cell. The body is clothed with short white hairs, especially on the face, legs, sides of median segment, and on the sides of posterior abdominal segments.

**Head** (fig. 1, *b*) more or less spherical, not quite transverse as in *flavipennis*; vertex behind ocelli broadly convex, smooth and shining. Ocelli placed on a slightly raised area, small and shining, the distance between the posterior ones and the front one not more than that between them and the eye on each side; in the region between the ocelli and antennae there are two or three fine longitudinal grooves. The antennae as long as body, scape stout, longer than broad, the flagellar joints not or but slightly longer than broad proximally, while the distal joints are distinctly longer; the joints have fine longitudinal grooves and are clothed with short hairs. The maxillary palpi long, the distal three joints being subequal.

**Thorax:** mesonotum smooth and shining, the parapsidal grooves distinct but not very deep. Pleurae smooth and shining. Metanotum comparatively smooth and shining above. Legs long, the posterior tibiae with two spurs.

**Wings** (fig. 1, *c, d*.) with the stigma large, much longer than broad. First abscissa of radius shorter than 2nd transcubital nervure; the first abscissa of the cubitus is distinctly curved, which makes the first cubital cell very narrow at the base; the basal vein is also curved where it bounds the first cubital. The submedian cell is distinctly smaller than the median, and the nervulus meets the median at some distance before its apex, the intervening distance being about two-thirds the breadth of the median cell at its apex. The second discoidal cell is elongate oval in shape, narrower anteriorly and broader posteriorly; the discoidens is distinctly rounded and more or less thickened at its junction with the other veins. The recurrent joins the first cubital just before its apex, and the parallel (subdiscoidens) is not interstitial.

**Abdomen** more or less rhomboidal, not longer than head and thorax. Tergites 2 to 4 smooth and shining, and all except the first broader than long; the first is longer than broad, with the usual mid-lateral longitudinal grooves and the median wedge-shaped area; the second segment almost quadrate, with the basal triangular area smooth and shining, and extending to a little beyond half the segment, the grooves along the sides of the triangle distinctly crenulate; in addition, the sides of the segment close to each lateral margin have also longitudinal grooves, more distinctly crenulated near the anterior angles of the segment. Third segment broader than long, smooth, there being a small shallow depression at each anterior angle of the segment; the suture between this and the second segment deeply impressed and finely crenulate. The remaining segments smooth. The ovipositor is a little longer than half the abdomen.

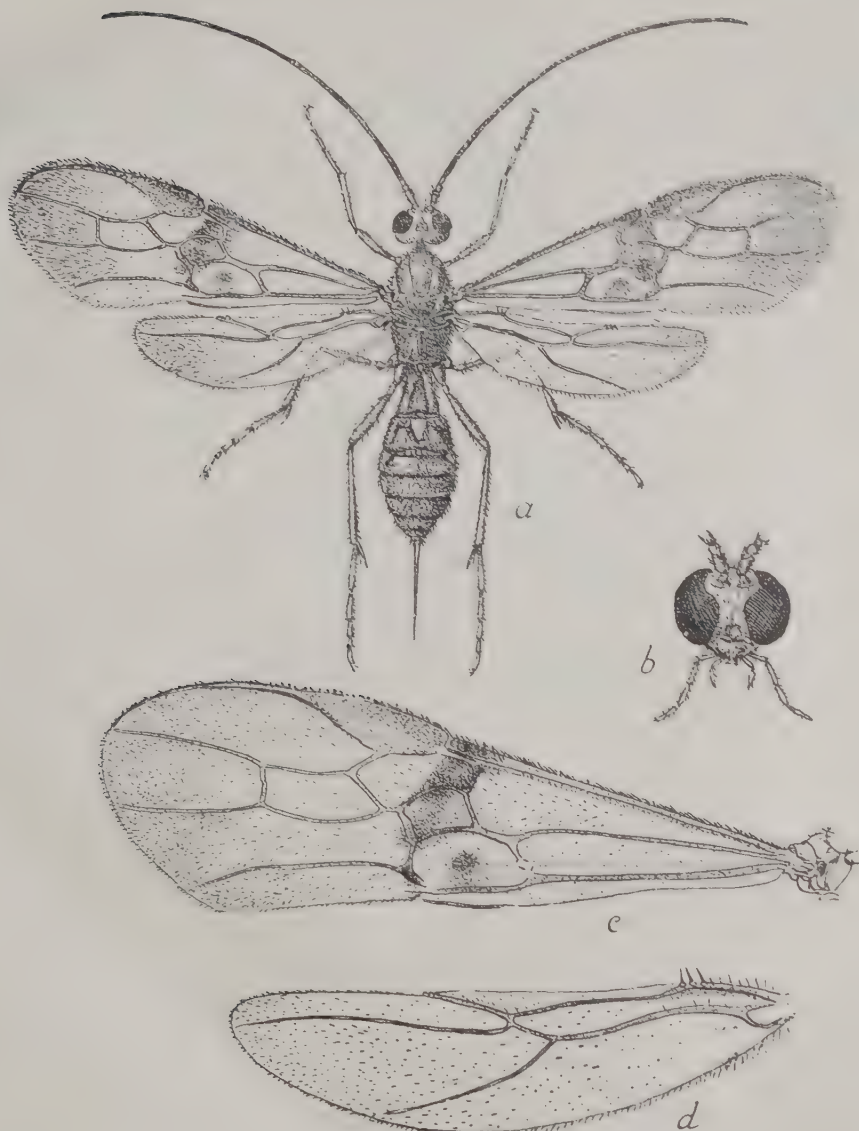


Fig. 1. *Aphrastobracon maculipennis*, sp. n.: a, female; b, head; c, fore wing; d, hind wing.

Length 7-8 mm.

SOUTH INDIA: Devanakonda, Kurnool, 15.viii.1913 (*Ramakrishna*); Nandyal, Kurnool, 28-30.ix.1917 (*P. V. Isaac*); Coimbatore, vii.1923 (*Ramakrishna*).

Described from five females.

(K 2945)

This species is quite distinct from *flavipennis*, Ashm., in its larger size, the shape of the head (which is not distinctly transverse), the colour of the wings, and in some other features. It differs from Enderlein's *gratiosus* and *guttifer* in the colour of the wings and tarsi. It approaches Baker's *philippinensis*, though it is clearly distinct in some features, especially in the wing colouration and the neurulation. The submedian cell is not so small in this insect as in *philippinensis*, nor is the second discoidal cell quite so long as in that species; the parallel (subdiscoideus) vein which is stated to be interstitial in that species is not so in *maculipennis*, in fact this interstitial position of the subdiscoideus is a non-Vipiine character according to Muesebeck.

These five species of the genus may be roughly distinguished by the following synoptical key, in which the colour markings alone are taken into consideration.

A. Wings flavo-hyaline with no markings. ... .. *flavipennis*, Ashm.

B. Wings flavo-hyaline with smoky brown markings.

(a) First cubital cell smoky brown at base and the costa above it black.

(i) Smoky brown only at the base of 1st cubital cell.

*philippinensis*, Baker.

(ii) Smoky brown markings in the two discoidal cells.

*maculipennis*, sp.n.

(b) First cubital cell and costa with no dark markings, but the distal portion of the wing brown, with a brown mark on stigma or a hyaline spot near the 3rd cubital cell.

(i) Stigma with a dark mark; all tarsal joints brown.

*gratiosus*, End.

(ii) A hyaline mark at apical third of the wing near 3rd cubital cell; only the first three hind tarsal joints brown.

*guttifer*, End.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st January and 31st March, 1926, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

- Mr. T. V. RAMAKRISHNA AIYAR :—4 Rhynchota ; from South India.  
 Mr. E. A. ANDREWS :—4 Diptera ; from Assam, India.  
 Dr. C. F. C. BEESON, Forest Entomologist :—27 Curculionidae, 52 Chalcididae, 21 Lepidoptera, and 28 Orthoptera ; from Dehra Dun, India.  
 Mr. LL. E. W. BEVAN :—80 Diptera ; from Southern Rhodesia.  
 Dr. F. S. BODENHEIMER :—345 Orthoptera ; from Palestine.  
 Mr. G. E. BODKIN, Government Entomologist :—35 Parasitic Hymenoptera, 15 other Hymenoptera and 30 cocoons, 1 species of Coccidae, and 2 Ticks ; from Palestine.  
 Dr. G. BONDAR :—14 Diptera, 4 Coleoptera, and 26 Chalcididae ; from Brazil.  
 Mr. H. E. BOX :—2 Coleoptera and 7 Parasitic Hymenoptera ; from Porto Rico.  
 Mr. G. BRIERLY :—1 Dermestid beetle ; from New Zealand.  
 Dr. P. A. BUXTON :—22 Siphonaptera, 15 Culicidae, 250 other Diptera, 222 Coleoptera, 165 Hymenoptera, 170 Lepidoptera and 10 cocoons, 5 species of Coccidae, 113 other Rhynchota, 42 Orthoptera, 24 Odonata, 4 Chrysopidae, 2 Hemerobiidae, 2 Ephemeridae, 15 Mallophaga, 100 Anoplura, 104 Mites, and 12 Spiders ; from Samoa, New Hebrides, and Cook Islands.  
 Mr. J. CLARK, Assistant Entomologist :—4 Coleoptera, 28 Hymenoptera, 82 Rhynchota, and 4 *Peripatus* ; from Western Australia.  
 Messrs. G. H. CORBETT and B. A. R. GATER :—249 Coleoptera, 5 Hymenoptera, 197 Lepidoptera, 30 Thysanoptera, 7 species of Aphidae, 1 species of Psyllidae, 260 other Rhynchota, and 28 Orthoptera ; from the Malay Peninsula.  
 Mr. D. D'EMMERZ DE CHARMOY :—40 Diptera and 1 species of Aphidae ; from Mauritius.  
 DIVISION OF ENTOMOLOGY, PRETORIA :—118 Coleoptera, 4 Hymenoptera, and 23 Rhynchota ; from South Africa.  
 Mr. P. R. DUPONT :—29 species of Coccidae ; from the Seychelles.  
 Mr. J. FERNANDEZ :—4 Culicidae, 6 other Diptera, 12 Coleoptera, 21 Hymenoptera, 28 Lepidoptera, 11 Isoptera, 3 Rhynchota, 11 Orthoptera, 17 Odonata, and 3 Trichoptera ; from Muscat.  
 Mr. C. FRENCH, Junr. :—1 species of Aphidae ; from Victoria, Australia.  
 Dr. L. FULMEK :—52 Curculionidae ; from Sumatra.  
 Mr. G. E. GATES :—2 Diptera ; from Burma.  
 Mr. F. D. GOLDING, Government Entomologist :—46 Rhynchota ; from Southern Nigeria.  
 GOVERNMENT MUSEUM, MADRAS :—9 Coleoptera ; from India.  
 Mr. C. C. GOWDEY, Government Entomologist :—4 Coleoptera, 6 Lepidoptera, 2 species of Aphidae, and 1 species of Coccidae ; from Jamaica.  
 Mr. W. GREENWOOD :—8 Diptera, 32 Coleoptera, 17 Parasitic Hymenoptera, 13 other Hymenoptera, 21 Lepidoptera, 21 Thysanoptera, 26 Rhynchota, 5 Psocidae, 12 Orthoptera, and 4 Chrysopidae ; from Fiji Islands.  
 Mr. G. L. R. HANCOCK, Assistant Entomologist :—11 Tabanidae, 12 other Diptera, 237 Coleoptera, 50 Parasitic Hymenoptera, 519 other Hymenoptera, 57 Lepidoptera, 1 species of Coccidae, 123 other Rhynchota, 4 Psocidae, and 2 Planipennia ; from Uganda.  
 Mr. E. HARGREAVES, Government Entomologist :—5 Tabanidae, 6 other Diptera, 35 Coleoptera, 32 Parasitic Hymenoptera, 10 other Hymenoptera, 3 Lepidoptera, 1 species of Coccidae, and 24 other Rhynchota ; from Sierra Leone.



Mr. H. HARGREAVES, Government Entomologist :—5 Coleoptera, 1,420 Parasitic Hymenoptera, and 6 Rhynchota ; from Uganda.

Dr. L. C. D. HERMITTE :—73 Tabanidae ; from Assam, India.

Major C. M. INGOLDBY :—3 *Tabanus* and 6 *Glossina* ; from the Gold Coast.

Dr. A. INGRAM :—32 Mites ; from South Africa.

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Mr. C. B. R. KING :—18 Lepidoptera ; from Nyasaland.

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Mr. N. C. E. MILLER :—1 species of Aleurodidae and 147 Orthoptera ; from Tanganyika Territory.

NATIONAL MUSEUM, MELBOURNE :—4 Coleoptera and 5 Orthoptera ; from Australia.

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Mr. A. H. RITCHIE, Government Entomologist :—20 Diptera, 75 Coleoptera, 15 Parasitic Hymenoptera, 14 other Hymenoptera, 78 Lepidoptera, 17 species of Coccidae, 7 other Rhynchota, 2 Orthoptera, and 3 Planipennia ; from Tanganyika Territory.

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Mr. O. H. SWEZEY :—5 Curculionidae and 6 Lepidoptera ; from Hawaii.

Mr. C. B. SYMES :—1 Dolichopodid fly and 4 early stages, and 19 Parasitic Hymenoptera ; from Kenya Colony.

Mr. H. P. THOMASSET :—2 Tabanidae, 25 other Diptera, 152 Coleoptera, 92 Hymenoptera, 229 Lepidoptera, 32 Rhynchota, 15 Orthoptera, 3 Trichoptera, and 2 Thysanura ; from Natal.

Dr. G. M. VEVERS :—25 Diptera, 63 Coleoptera, and 13 Hymenoptera ; from British Guiana.

Mr. H. WHISTLER :—243 Orthoptera ; from India.

Mr. D. S. WILKINSON, Government Entomologist :—53 Diptera, 37 Coleoptera, 40 Parasitic Hymenoptera, 42 Formicidae, 12 Lepidoptera, and 26 Rhynchota ; from Cyprus.

Mr. C. L. WITHEYCOMBE :—9 Dipterous larvae ; from British Guiana.

## MOSQUITO NOTES.—VI.

By F. W. EDWARDS.

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I. THE RACES OF *ÆDES VARIEGATUS* (DOL.).

*Aedes* (*Stegomyia*) *variegatus* (Dol.) is a widely-spread species in the Australasian region, and under its synonym of *Stegomyia pseudoscutellaris* is well-known as the carrier of filaria in Fiji and Polynesia in general. Up to the present the existence of definite local variations has not been suspected, partly because the species itself has been regarded as the Australasian representative of the Oriental *A. albopictus* (Skuse). Recently, however, Dr. P. A. Buxton has discovered that larvae from Samoa and the New Hebrides differ in a constant manner, and at his suggestion I have scrutinised the whole series of specimens of this species in the British Museum. This examination appears to show that there are at least five distinct varieties, distinguishable by small differences of colour and also by the male hypopygium, especially in the form of the basal lobe of the side-piece. The characters are fairly well defined, but are perhaps best treated as varietal rather than specific, especially as their significance appears to be mainly geographical.

Since *A. variegatus* has such a wide distribution in the Pacific, it is a little surprising that it does not appear to have reached the Hawaiian Islands, the only representative of the group there being *A. albopictus* (Skuse), which is presumably to be regarded as a recent introduction from China or Japan. In my synopsis of the Australasian mosquitos (Bull. Ent. Res. xiv, p. 371, 1924) I have indicated several points of difference between *A. albopictus* and *A. variegatus*; practically all of these hold good as regards all the forms of the latter species mentioned below. One small error, however, must be corrected. Perfect specimens of *A. variegatus* (all varieties) show that the apex of the median lobe of the scutellum is not bare, but carries a few black scales, so that the edge of the white area of the whole scutellum forms a straight line.

***Aedes variegatus* (Dol.), type form.**

Doleschall described the species from Amboina; Walker's type of *Culex scutellaris* came from the neighbouring Aru Islands. I have seen no males from there, but the type of *C. scutellaris* agrees, so far as can be seen, with that of *C. zonatipes*, Walk., from New Guinea, and with a female from Ile Deslacs (*Biro*), another from Rabaul, New Britain (*Hill*), and some specimens from Tulagi, Solomon Islands (*Carment*), and Port Purvis, Gela, Solomon Islands (*C. H. G. White*). The last two lots mentioned were reared from coconut husk, and include males as well as females; they may

provisionally be regarded as representing the typical form of the species. They exhibit the following characters :—

Dorsal white bands of abdomen complete and nearly touching the bases of the segments in the middle ; they are present on each of tergites 3-7 in the female, and there is usually also some trace of a band on tergite 2. Third and following sternites with black apical bands. Hind femur with a large white spot at the tip. Hind tarsal rings broad, that on the fourth segment occupying almost the basal four-fifths.

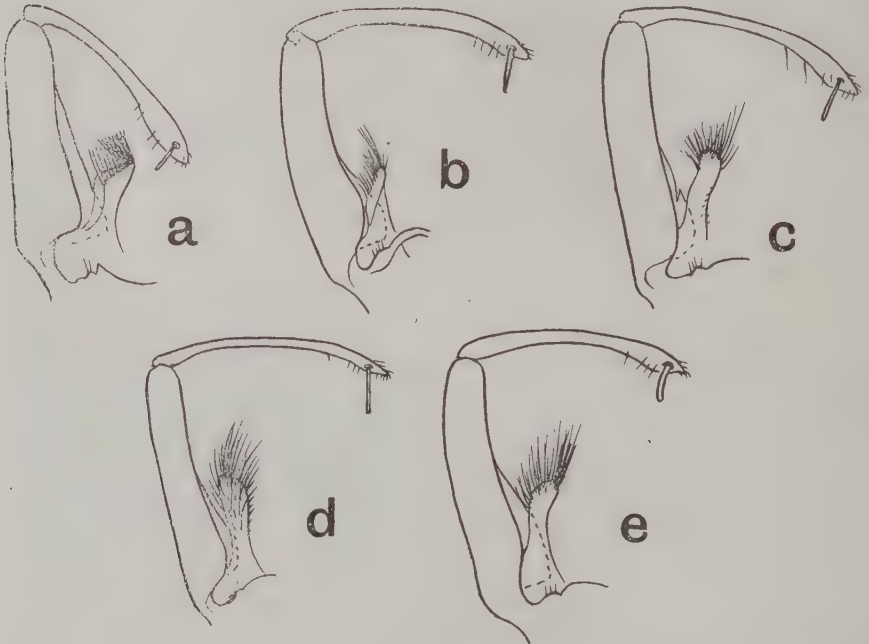


Fig. 1. Male hypopygium of races of *Aedes variegatus* (hairs of side-piece omitted) : *a*, type form (Solomon Is.) ; *b*, var. *hebrideus* (New Hebrides) ; *c*, var. *tongae* (Tonga Is.) ; *d*, var. *pseudoscutellaris* (Samoa) ; *e*, var. *andrewsi* (Christmas I.).

Hypopygium (fig. 1, *a*) : Side-piece barely three times as long as its breadth at the base. Basal lobe flat-ended, with a regular row of equally long hairs round most of the apical margin. Clasper moderately stout, somewhat swollen at the tip, spine rather slender. Middle part of ninth tergite emarginate.

#### **A. *variegatus* var. *hebrideus*, nov.**

Colour practically as in the type form ; the abdomen with complete and distinct dorsal white bands on tergites 4-7, sometimes also on 3, but apparently never on 2 ; the bands are further removed from the bases of the segments than in the type form, being placed at about one-third the distance from the base.

Hypopygium (fig. 1, *b*) : Side-piece about  $3.5 \times 1$ . Basal lobe rather small, conical, hairy round the tip ; most of the hairs rather short, but a group of about three longer ones at the tip. Clasper stout, not swollen at tip, spine stout and pointed. Middle part of ninth tergite convex.

NEW HEBRIDES: Espiritu Santo, Hog Harbour, vi-viii.1925, type ♂ and 1♀; also Vila and Undine Bay, Efate Is.; Atchin Is.; Ambryn I., and Tanna, vii.1925—numerous specimens (*P. A. Buxton*). Zagabé, 16.iv.1914, 1♂ 1♀ presented to British Museum by French Government in 1915. BANKS GROUP (*Dr. A. E. Ridsdale*), 1♀.

**A. variegatus** var. **tongae**, nov.

Dorsal bands of abdomen rather variable; sometimes broadly interrupted or absent, especially in the female; when present they are less pure white than in the type form or the var. *hebrideus*, and the band on tergite 7 is nearly always absent, as well as that on tergite 2; the bands are less distinct and placed near the bases of the segments. White rings of hind tarsi rather narrow, that on the fourth segment occupying only the basal half.

Hypopygium (fig. 1, c): Similar to that of the var. *pseudoscutellaris*, but basal lobe of side-piece hairy at the tip only, and the hairs rather shorter; clasper considerably swollen at the tip.

TONGA IS.: Haapai, 26.ii.25, type ♂ and 2♀; Nukualofa, 24.ii.25, 1♂ 2♀ (*G. H. E. Hopkins*); Vavau, 1♂ 3♀ (*C. L. Edwards*). SOLOMON IS.: Sikiana, 1925, 7♂ 4♀ reared from larvae in coconut shell (*C. H. G. White*, per *Dr. A. C. Carment*).

**A. variegatus** var. **pseudoscutellaris** (Theo.).

This was described from Fiji, and all specimens examined from there and from Samoa agree closely; males have also been examined from Tautira and Papeete, Tahiti (*Miss Cheesman* and *H. W. Smith*). A female from the Cook Is. (*Dr. J. P. Donald*), and others from Fakarawa, Tuamotu Is., and Nuka-Hiva and Tahuata, Marquesas Is. (*Miss Cheesman*), also appear to belong to this variety.

White bands on abdominal tergites broadly interrupted dorsally in the female. Third and following sternites with black apical bands. Hind femur with a large white spot at the tip. White rings of hind tarsi broad, that on the fourth segment occupying about the basal two-thirds.

Hypopygium (fig. 1, d): Side-piece long and slender, over four times as long as its breadth at the base. Basal lobe large, tip rounded, hairy on the apical half or more, but the hairs at the tip longer. Clasper very slender, tip not swollen, spine long and slender. Middle part of ninth tergite convex.

**A. variegatus** var. **andrewsi**, nov.

Hind femora with a very small white spot at the tip, chiefly on the outer side. Fourth hind tarsal segment usually with less than the basal half white. First four abdominal sternites practically all white; tergites with lunate lateral spots only, which are smaller than in the other varieties and less brilliantly white. Median line of thorax sometimes with a creamy tinge, but in other specimens pure white as in the other varieties.

Hypopygium (fig. 1, e): Side-piece about 3.5×1. Basal lobe large, tip rather rounded and densely hairy; dorsal hairs long, ventral hairs shorter and denser. Clasper moderately stout, slightly swollen at tip; spine stout, blunt, and slightly curved. Middle part of ninth tergite somewhat convex.

CHRISTMAS IS. (S. of Java): i.1898 and x.1908 (*Dr. C. W. Andrews*); iii.1902 (*Dr. Durham*); x.1910 (*Dr. R. Kirkpatrick*).

## II. THE SPECIES OF THE *KOCHI* GROUP OF THE SUBGENUS *FINLAYA*.

*Aedes kochi* (Dön.) was originally described from New Guinea, and has subsequently been taken again on that and neighbouring islands, the larvae being said



by Hill to live in coconut husks. It belongs to a small group of species which are well distinguished from other members of the subgenus *Finlaya* by their elaborately spotted wings and legs. In the Tongan and Samoan islands a very similar species is found which breeds only in the axils of the leaves of the taro, an edible Aroid, and never in coconuts. The Samoan species has been given a separate name (*F. samoana*, Grünb.), but until now I have regarded it as identical with *A. kochi*. Dr. P. A. Buxton has, however, called my attention to the foregoing facts as to the sharp distinction in distribution and larval habits between *A. kochi* and *A. samoana*, and has stated his opinion that the two are most probably distinct species or varieties. At his suggestion I have re-examined the material in the British Museum, with the object of discovering what difference, if any, existed between the adults. Unfortunately the former is represented in the National Collection by a few damaged females only. Mr. G. F. Hill, however, has kindly lent fresh specimens from New Britain and New Ireland, and with the assistance of these it has been possible to arrive at a definite conclusion. One of the specimens sent by Mr. Hill proved to belong to a new species, making a total of five forms known in this group. These may be distinguished by the following key:—

1. Hind tarsi with white rings at the tips of the first three segments, those on the second and third segments occupying about as much space as the black basal part; fourth segment all black, fifth all white ... .. 2  
Hind tarsi more extensively pale, the second and third segments having only narrow black rings at the base ... .. 4
2. General colour black, markings pure white; all the veins with numerous small white dots; sternites 5–7 in ♀ with outstanding scales...*poicilia*, Theo.  
General colour lighter; wing-markings very variable, but the light areas either not dot-like or else much less numerous ... .. 3
3. Sternites 5–7 of ♀ abdomen with outstanding black scales; pale markings of wings and legs with little or no yellow tinge ... .. *kochi*, Dön.  
No outstanding scales at end of sternite 5, though they are present on 6 and 7; pale markings of wings, femora and tibiae more or less strongly tinged with yellow ... .. *samoana*, Grünb.
4. Proboscis black, with a yellow ring in the middle and a narrow yellow tip; fourth hind tarsal segment all black; sternites 5–7 with outstanding scales apically ... .. *wallacei*, sp. n.  
Proboscis and hind tarsi mainly yellow, the fourth hind tarsal segment with a narrow dark basal ring; sternites 4–7 with outstanding scales  
*flavipennis*, Giles.

#### A. (F.) *kochi* var. *poicilia* (Theo.).

Represented in the British Museum from the Philippine Is., Borneo, Sumatra and Malay Peninsula. As stated in my revision of Australasian mosquitos, it is probable that records of the species from Papua and Queensland refer to *A. kochi*. The only male available is one from the Philippines; the hypopygium of this has been mounted and shows the following features: Side-piece with a tuft of very long, broadly lanceolate scales on the inner side beyond the middle; basal area only slightly hairy; appendage of claspette not very broad.

This is clearly the Oriental representative of *A. kochi*, and is therefore best regarded as a variety of that species, the differences being very slight.

#### A. (F.) *kochi* (Dön.), type form.

The specimens of this which I have examined are all females; one from Dreger Hafen, Cap Cretin, Papua (*Dönitz*); one from Rabaul, New Britain (*G. F. Hill*);

one from Kaewung, New Ireland (*Dr. H. G. Wallace*) ; one from Tulagi, Solomon Is. (*Dr. A. G. Carment*) ; four from Suva, Fiji, 1910 (*Dr. P. H. Bahr*) ; and two labelled Philippine Is. (*C. S. Banks*) ; these last are probably wrongly labelled and may possibly have come from Queensland.

In all the specimens the presence of outstanding black scales on the apical part of the fifth abdominal sternite is noticeable ; in this respect they resemble both *A. poicilia* and the new species described below.

**A. (F.) kochi** var. **samoana** (Grünb.).

A long series of both sexes of this species is available for study, all from Upolu, Samoa and Nukualofa, Tonga.

The absence of outstanding scales on the apical part of the fifth abdominal sternite of the female appears constant and offers an easy and sharp distinction from typical *kochi*. No constant difference between these varieties could be detected in the markings, apart from the strong tendency to yellow on the wings and legs shown by var. *samoana*. The male hypopygium of this variety differs slightly from that of var. *poicilia* ; the scales in the tuft of the side-piece are perhaps rather shorter and narrower ; basal area more densely hairy ; and appendage of claspette broader.

**A. (F.) wallacei**, sp. n.

Very similar to *A. (F.) kochi*, differing in the following points : Median ring and apical spot on proboscis yellow instead of white, as are also the flat scales on the pronotal lobes, as well as many of the mesonotal scales. Pale markings of wings, femora and tibiae suffused with yellow as in *A. (F.) samoana*. First hind tarsal segment with two narrow yellow rings as well as the narrow white one in the middle and the broader white ones at the base and tip ; second and third hind tarsal segments mainly white, with a narrow black ring at the base, followed immediately by a narrow yellow ring. Pale areas of wing much more extensive than the dark, of which there are three conspicuous spots on the costa (but the wing-markings are doubtless variable, as in *A. kochi* var. *samoana*).

NEW IRELAND : Kaewung (*Dr. H. G. Wallace*). Type ♀ returned to Mr. Hill.

Although this is certainly closely related to typical *A. kochi*, it is almost certainly distinct on account of the conspicuous difference in the markings of the hind tarsi, which somewhat resemble those of *A. flavipennis*.

**A. (F.) flavipennis** (Giles) (*lutea* Ludl. ; *aranetana* Banks).

This very distinct species has been recorded only from the Philippines, but has recently been found by Dr. D. H. C. Given at Singapore. The hypopygium of the male hardly differs from that of *A. poicilia*.

### III. NEW CULEX FROM AUSTRALASIAN ISLANDS.

**Culex** (? **Culiciomyia**) **atriceps**, sp. n.

♀. *Head* with blackish integument, clothed above with numerous erect black scales and close-lying narrow dark brown ones, contrasting strongly with a border of rather broader but still narrow pure white ones round the eye-margins. Clypeus and tori blackish, the latter with a conspicuous dusting of grey. Proboscis black-scaled, as long as the front femora. Palpi black-scaled, about one-fifth as long as the proboscis. *Thorax* : Mesonotum with dull reddish-brown integument, clothed with small narrow scales of a similar colour. Anterior pronotal lobes clothed with pure white scales, which are mostly quite narrow, but have mixed with them a few

broader ones. Posterior pronotal lobes dark-brown, somewhat shining, bare. Pleurae mostly dark brown, but the sutures pale, and a narrow ill-defined pale stripe covered with white flat scales above the middle; a small group of white scales on the lower part of the sternopleura. One strong dark lower mesepimeral bristle. *Abdomen* with light brown integument; black-scaled dorsally, tergites with basal lateral white spots, first tergite bare except for hairs and a small median patch of scales. Sternites dark apically, pale basally. *Legs* with pale unscaled coxae, remainder clothed mainly with blackish scales, except for the undersides of the femora and conspicuous white knee-spots on all the femora; hind femora dark outwardly on about the apical fourth, the dark dorsal line hardly reaching beyond the middle. Claws and pulvilli normal. *Wings* normal; scales narrow and all dark; upper fork-cell 5-6 times as long as its stem. Halteres all yellow. Wing-length 3.5 mm.

TAHITI: Papeari, 18.viii.1924 (*Harrison W. Smith*); 1 ♀.

This species appears well characterised, especially by the scaling of the head and pronotal lobes, which is unlike that of any known Oriental or Australasian species. The male should be easily recognised when discovered.

***Culex (Lophoceratomyia) hilli* var. *buxtoni*, nov.**

Closely resembles *C. hilli*, Edw. (Northern Australia), except in the following details: Sixth antennal with about 12 very narrow but blunt-ended scales, which are fully half as long as the hairs of the verticil; tenth segment with three or four hair-like scales similar to those of the eleventh; last two segments subequal in length. Outer division of lobe of side-piece with a narrow twisted leaf which is almost as long as the three rods of the inner division of the lobe.



Fig. 2. *Culex (Lophoceratomyia) hilli*, var. *buxtoni*, nov.: a, base of left palp from beneath, showing the finger-like projections. *Culex femineus*, sp. n.: c, lobe of side-piece and clasper; b, aedeagus and half anal segment.

NEW HEBRIDES: Vila, Efate Island, vii.1925, 1 ♂ (*P. A. Buxton*).

My description of *C. hilli* was inaccurate in stating the palpi to be bare; in reality there are a few short hairs on the last two segments, which are rather more numerous in the variety. The hypopygium is practically identical in the type and variety, and resembles that of *C. fraudatrix* as figured by Barraud, the clasper almost regularly

tapering, very slightly swollen before the tip; side-piece with only three inconspicuous hairs at the base beneath; lobe of mesosome with downwardly projecting point.

In several species of this subgenus, including *L. hilli*, the palpi of the male have been described as having a small finger-like projection at the base on the outer side. Actually when these structures are present there are two at the base of each palp, the inner one having been overlooked. In *C. hilli* they are hairy at the tips, forming a pair of tiny brushes facing one another. As shown in the accompanying figure (fig. 2, a) they spring from the ventral surface of the palp at the extreme base. Their development varies in different species of the subgenus; most frequently they are entirely absent, and no such structures occur in *Culex fatigans* or *Aedes argenteus*, which have been examined for comparison.

***Culex femineus*, sp. n. (fig. 2, b, c).**

*Head* without any flat scales; except at the sides; all the dorsal scales brown, those round the eye-margins scarcely lighter than the rest. Bristles all dark. Clypeus dark brownish, rather long, unscaled. Palpi alike in the two sexes, exceeding the clypeus by nearly twice its length. Proboscis dark, slightly longer than the front femora. Antennae of ♂ very inconspicuously plumose, as long as the proboscis; last two segments together scarcely half as long as the remainder; verticils sub-basally placed and composed of 8 hairs only, the longest of which are only about four times as long as the segment bearing them; no distinct secondary verticil at the tip. Tori yellowish, unscaled. Antennae of ♀ normal. *Thorax* with the integument of mesonotum dull dark brown, lighter on the shoulders; scales all small, narrow, brown; bristles rather numerous and long. Pleurae unscaled, dark brown; an ill-defined light band across the middle; lower part of sternopleura greenish. One distinct lower mesepimeral bristle present. *Abdomen* dark brown; tergites with somewhat rectangular basal lateral creamy patches; sternites with ill-defined basal pale bands. *Hypopygium* small; side-pieces without scales; lobe simple, with three strong spines, beyond it several bristles; no leaf; clasper short, with stout terminal claw; tenth sternite without basal arm, and with a number of tubercles instead of spines or setae at the tip; halves of mesosome long, slender, pointed. *Legs* dark brown; undersides of femora lighter. First hind tarsal segment slightly longer than the tibia. Larger claw on front and middle legs of ♂ with one tooth. *Wings* with dark brown scales, all rather narrow. Upper fork-cell barely twice as long as its stem. Halteres with pale stem and dark knob. Wing-length, 2.5-3 mm.

NEW HEBRIDES: Espiritu Santo, Hog Harbour, vii.1925 (*P. A. Buxton*); type ♂, paratypes 5♀ 6♀ in the British Museum.

This interesting new species seems most nearly allied to *C. cataractarum*, Edw. (New Britain), which differs in the scaling of the head, longer verticils of ♂ antennae (though these also comprise about 8 hairs, not 4-5 as stated in the description), absence of lower mesepimeral bristle and of abdominal markings, etc.

***Culex bihamatus*, sp. n.**

♂. Rather closely resembles *C. vicinus*, Taylor (Australia), differing externally in having practically the whole of the mesonotum clothed with narrow white scales, instead of the anterior two-thirds only; a few dark scales can, however, be detected a little above the roots of the wings and at the junction of the middle and posterior thirds; all femora distinctly mottled with pale scales in front; upper fork-cell rather shorter than in *C. vicinus*, its base distinctly beyond that of the lower. As in *C. vicinus* the white rings of the hind tarsi are distinct and almost confined to the bases



of the segments, and the wing-scales are rather narrow. *Hypopygium*: Side-piece with a small lobe which bears two rather stout and blunt spines; no distinct leaf, the structure being represented by a flattened, blunt-tipped bristle. Clasper sickle-shaped, evenly tapering. Tenth sternite without distinct basal arm. Mesosome consisting of two pairs of almost separate and almost equal curved hooks, both rather slender and sharply pointed, one pointing downwards and the other outwards. The hypopygium of *C. vicinus* is very similarly constructed, but the outwardly-directed hook of the mesosome is much stouter and almost rounded at the tip.

TIMOR: *Atamboea* (*Dr. Labaar*); type ♂ (unique) presented to the British Museum by Dr. S. L. Brug.

### ***Culex trifidus*, sp. n.**

*Head* clothed with flat whitish scales at the sides and round the eyes; narrow creamy ones behind; upright scales brown. Clypeus pale. Bristles dark. Proboscis dark brown, without any hair-tuft beneath, tip not swollen. Palpi dark brown, longer than the proboscis by about half the length of the last segment; long segment with the constriction much before the middle; last two segments together not half as long as the long segment; penultimate with long fine hairs on the inner side, bare outwardly; terminal segment short-haired. Antennae with well-developed plumes, basal segment yellowish. *Thorax* dull reddish brown above, pleurae pale. Mesonotal scales rather coarse, dark brown; no scales on pronotal lobes or pleurae; one strong lower mesepimeral bristle. *Abdomen* blackish above, tergites 3-7 with narrow white apical bands of about even width; traces of such a band also on tergite 2. Sternites brownish. *Hypopygium* large and of remarkably complicated structure. Ninth tergite membranous and without hairs. Side pieces without scales, densely bristly on the outer side, much swollen as far as the lobe, the distal part more slender; lobe large, deeply divided into two finger-like portions, the basal one the larger and longer, bearing near its base two long black lanceolate blades placed close together, and appearing almost as one oval blade drawn out into a long point, beyond these are two spines, one very stout with slightly hooked tip, and beyond these the lobe-division is produced further to a truncate tip which is provided with a close-set black comb; apical division of lobe slender, with two terminal spines. Clasper divided to near the base into two arms, the main outer one stout, with the tip expanded and somewhat hammer-shaped, terminal spine moderate; the other arm shorter, divided at about the middle of its length into two equal parts, one continuing the direction of the basal part, the other at right angles to it, both with somewhat hammer-shaped tips. Tenth sternites almost membranous, part of the tip produced into a pubescent flap, the other part bearing a regular and very close-set black comb. Halves of mesosome long, slender, pointed, simple. *Legs* dark brown, unmarked, femora pale beneath, the hind femora pale almost to the tip on the outer side. Front claws subequal, the larger with a stout tooth about the middle; mid claws more unequal, the larger with a more slender tooth before the middle. *Wings* with scanty brown scales, the outstanding ones very few in number at the tip only; anal vein almost bare. Fork-cells very short, the upper scarcely half as long as its stem. Cross-veins separated by about three times the length of the posterior. Halteres ochreous. Wing-length 3 mm.

LESSER SUNDA IS.: Alor, i.1926 (*Prof. Rodenwaldt*). Type ♂ presented to the British Museum by Dr. S. L. Brug.

This is an extremely distinct species by the structure of the hypopygium, and also by the remarkably short fork-cells and the vestiture of the palpi. In colouring it resembles species of the *Neoculex* group, such as the European and N. American *C. apicalis* or the E. Australian *C. fergusoni*; it is doubtful, however, whether it is at all related to these species.

## IV. ADDITIONAL RECORDS FROM THE SOLOMON ISLANDS.

In a recent paper (Bull. Ent. Res., xv, p. 257, 1925) I gave a list of the mosquitos known from the Solomon Is., based almost entirely on material collected by Dr. A. G. Carment. Before leaving the islands early in the present year, Dr. Carment sent home further collections, which contained, besides the missing males of two species, examples of ten additional species, bringing the total number of mosquitos known from the islands up to 22. The specimens from Gela Island were obtained as larvae by Mr. C. H. G. White and forwarded by Dr. Carment.

**Rachionotomyia quasiornata** (Taylor).

One female from Marovovo Village, Guadalcanar I., x.1925.

**Rachionotomyia solomonis**, Edw.

Port Purvis, Gela (C. H. G. White) ; a series reared from larvae found in a coconut husk, in company with *Aedes argenteus*, *A. variegatus*, and several other species mentioned below.

The characters mentioned as diagnostic in my original description appear to be constant. In addition it may be noted that the male palpi are about three-quarters as long as the proboscis.

**Uranotaenia nigerrima**, Taylor.

One female, in company with the last.

**Taeniorhynchus (Mansonioides) uniformis**, Theo.

Marovovo village, Guadalcanar Is., x.1925, 2 ♀.

**Armigeres breinli** (Taylor).

Port Purvis, Gela (C. H. G. White) ; a series reared from larvae found in a coconut husk. The male hypopygium agrees with Taylor's figure.

**Aedes (Stegomyia) edwardsi**, Barr., var. **tulagiensis**, nov.

Differs from typical *A. edwardsi* as follows : The small white spot near the front margin of the mesonotum is elongate oval instead of nearly round ; the posterior pronotal lobes have numerous narrow black scales on their upper part, in addition to the small patch of flat white scales below, whereas in the type the white scales alone are present ; and the dark dorsal stripe of the hind femora widens gradually from the base to the tip, instead of widening suddenly a little beyond the middle.

Type and one other female near Tulagi Hospital, Santa Cruz I., i.1926. The occurrence of this species in the Solomons is most unexpected, as it has hitherto been found only in the Andamans. It is very distinct from other species of the subgenus by the single small white spot on the mesonotum.

**Aedes (Stegomyia) variegatus** var. **tongae**, Edw.

Sikiana, a series reared from larvae found in a coconut shell. This new variety has been defined in another section of this paper. It was first noted from the Tonga Is., and its subsequent discovery in the Solomons is of much interest.

**Aëdes (*Stegomyia*?) *albolineatus*, Theo.**

Port Purvis, Gela, reared from coconut husk. Siota, Gela, reared from tree-hole.

This Oriental species has already been recorded from New Ireland and the Russell Is. It is not a true *Stegomyia*, the hypopygium being more like that of the subgenus *Aëdimorphus*; the spine of the clasper is placed far before the tip, as in such African species as *A. furcifer*.

**Aëdes (*Skusea*) *amesi* (Ludl.).**

Siota, Gela, 4 ♀ reared from tree-hole. This differs from most other species of the subgenus in having neither bristles nor hairs on the lower part of the mesepimeron.

**Aëdes (*Skusea*) *funereus* var. *ornatus*, Theo.**

Taro swamp, Sikiana, midday, 13.iii.1925, 5 ♀.

**Aëdes (*Finlaya*) *kochi*, Dön.**

Tulagi, viii.1925, 1 ♀ in house, morning.

**Aëdes (*Finlaya*) *albilabris*, Edw.**

Port Purvis, Gela, series reared from coconut husk. Siota, Gela, series reared from tree-hole. Also several additional specimens from Tulagi.

The species was described from the female only. All the males now examined differ from the females in lacking the white patch at the tip of the proboscis. They have the palpi fully as long as the proboscis, the last segment entirely white above, the penultimate one mainly so. Hypopygium of the normal type of the subgenus; claspers very short; terminal spine long, not much shorter than the clasper itself; side-piece without scale-tuft, but the hairs in a small area a little before the tip on the inner side have their tips somewhat flattened.

**Culex (*Lophoceratomyia*) *hilli*, Edw. ?**

Two females taken on schooner, Graciosa Bay, Santa Cruz I., in company with a number of *Anopheles punctulatus*, Dön. In the absence of the male the identity is uncertain.

## V. ON A COLLECTION FROM TASMANIA AND S.E. AUSTRALIA.

The insects noted below were mostly obtained by Mr. A. Tonnoir, now of the Canterbury Museum, N.Z., during visits to Australia in 1921 and 1922-3. Apart from the new species, several of these records are of interest as extending the known range of Tasmanian species to the mainland or *vice versa*.

***Rachionotomyia tasmaniensis* (Str.).**

TASMANIA: Advent Bay, Eaglehawk, Geeveston, King R., Cradle Valley, Mt. Farrel, Harz Mt., Mt. Wellington. VICTORIA: Sassafras. NEW SOUTH WALES: Waterfall.

The New South Wales specimen has the last hind tarsal segments darkened above, whitish at the sides and beneath.

***Theobaldia frenchi* (Theo.).**

VICTORIA: Sassafras, 20.x.22, 1 ♂ 2 ♀.

These specimens agree very well with Theobald's original series, consisting of females only from an unrecorded locality in Victoria. The following points appear to be characteristic of the species :—

Upright scales of the head dark, at least those towards the neck. Male palpi slightly longer than the proboscis, densely hairy apically (much as in *Culex pipiens*), the last segment over half as long as the penultimate. Thoracic integument uniformly reddish; mesonotal scales all golden. Anterior and posterior pronotal lobes each with a few narrow pale scales. Middle part of mesepimeron with a distinct patch of scales, but with few short hairs. Scales of abdominal sternites nearly all ochreous, at least in the female. Lobes of ninth tergite of male hypopygium each with a patch of about 12 slender curved hairs. Side-pieces well over twice as long as broad; basal lobe hardly reaching two-thirds of the length of the side-piece; indistinctly separated except towards the tip, which bears a small tuft of rather short hairs. Clasper very slender, evenly tapering and slightly curved, terminal spine short. Aedeagus rather large and strongly chitinised. Tarsi becoming pale apically, the last two segments clothed entirely with ochreous scales. Wings with a slight darkening of the membrane in the outer third of the upper basal cell.

### **Theobaldia hilli, sp. n.**

In my revision of Australasian CULICIDAE (Bull. Ent. Res. 1924) I referred to *T. frenchi*, Theo., a number of specimens taken at Beaconsfield, Victoria, 6.xi.1923 and 8.xii.1923 (G. F. Hill). Closer study of these in the light of Mr. Tonnoir's fresh material shows that they are not *T. frenchi*, but belong to an allied distinct species, differing from *T. frenchi*, thus :—

Male palpi scarcely as long as the proboscis, the last two segments with shorter and scantier hair, terminal segment scarcely half as long as the penultimate. Thorax rather darker as a whole, but the pleural integument not uniformly coloured, the posterior pronotal lobes (proepimera), the post-spiracular sclerite, the subalar knob and the meron (the triangular piece between the posterior coxae) being considerably darker than the remainder. Mesonotal scales rather lighter and larger.

Hypopygium similar to that of *T. frenchi*, but the side-pieces only about twice as long as broad, basal lobe larger, more separated and reaching nearly to the tip of the side-piece, its tip more densely hairy and curved downwards towards the anal segment; clasper less tapering, slightly twisted at the tip. No dark cloud on the wing-membrane.

### **Theobaldia weindorferi, sp. n.**

Similar to *T. frenchi* (Theo.), differing as follows :—

Upright scales of head all yellow (in type). Male palpi of the same length as the proboscis, last segment about two-thirds as long as the penultimate. Mesonotal scales mostly dark brown, very narrow and almost hair-like; a few golden ones round the front margin and towards the scutellum, and generally a pair of small patches of golden scales about the middle. No scales either on the anterior or posterior pronotal lobes, though the latter sometimes have a very few short dark hairs representing the scales. Middle part of mesepimeron with a very few scales, but with rather numerous short fine hairs. Scales of abdominal sternites mostly purplish, but not so dark as those of the tergites. Lobes of ninth tergite of male hypopygium with a posterior row of about 4–6 stiff bristly hairs. Side-pieces more pointed; basal lobe rather shorter, but with a longer and denser apical hair-tuft. Terminal spine of clasper longer and more slender. Aedeagus smaller and less strongly chitinised. Tarsi all dark to the tips. Wings rather more densely scaled, but without any darkening of the membrane.



TASMANIA: Cradle Valley, 12.i.1923, type ♂; Harz Mt., 9.ii.1923, 1 ♀.

The last-mentioned specimen differs from the other in having the upright scales of the head dark. This cannot be *T. littleri* (Tayl.), the only species of the genus hitherto reported from Tasmania, owing to the dark tarsi, dark mesonotal scales, and absence of scales on the pronotal lobes. Whether *T. littleri* is distinct from *T. frenchi* remains to be ascertained.

A female from Mt. Wilson, New South Wales, 19.xi.1921, resembles *T. weindorferi* in its entirely dark tarsi, but the upright scales of the head are dark, the mesonotal scales paler, and the proboscis ochreous beneath. It may be a variation of *T. weindorferi*, or perhaps another distinct species.

***Aëdes (Ochlerotatus) andersoni*, nom. n.**

*Andersonia tasmaniensis*, Strickland, Entom. xliv, p. 250 (July 1911).

TASMANIA: St. Patrick R., 30.x.1922, 3 ♂; Mt. Field, 19.xii.1922, 8 ♀; Mt. Farrel, 9.ii.1923, 1 ♀; Cradle Valley, 11.i.1923, 2 ♀; Eaglehawk N., 16.xi.1922, 1 ♀; Geeveston, 7.xii.1922, 1 ♀. VICTORIA: Lower Tarwin, xi.1925, 4 ♀ (*G. F. Hill*).

In my revision I identified this species with *A. nigrithorax* (Mcq.), but this now proves to be erroneous, and it therefore becomes necessary to rename Strickland's species. The hypopygium of the males obtained by Mr. Tonnoir differs very much from that of *A. nigrithorax*, and shows the following features:—

Lobes of ninth tergite small, with 4–6 short bristles. Side-pieces with the basal lobes large, flattened, prominent; a row of long hairs along the margin, and two tergally placed bristly spines, one long with slender curved tip, the other short and straight. Apical lobe well developed but practically bare. Claspers not much swollen, slightly tapering, apical spine long. Claspettes with long stem without basal thumb, appendage flattened but not very broad, without angle at base.

The male palpi are as long as the proboscis.

***Aëdes (Ochlerotatus) cunabulanus*, Edw.**

TASMANIA: Cradle Valley, 11–27.i.1923, 3 ♂ 4 ♀; Mt. Farrel, 9.ii.1923, 1 ♂; Mt. Field, 18.xii.1922, 1 ♀; Fern Tree, ii.xi.1922, 1 ♀; Mt. Wellington, 2.xii.1922, 1 ♀; St. Patrick R., 1.xi.1922, 1 ♀; Strahan, 6.ii.1923, 1 ♀.

The hypopygium is practically identical in structure with that of *A. andersoni*, the appendage of the claspettes appearing a little broader. The absence of flat white scales above the wing-base is a good distinction from *A. andersoni*, but perfect specimens show the same flat black scales on the posterior pronotal lobes. In some of the females the abdominal bands are incomplete.

***Aëdes (Ochlerotatus) nivalis*, nom. n.**

*Culex australis*, Theobald (*nec* Erichson), Mon. Cul. ii, p. 91 (1901).

TASMANIA: Mt. Wellington, 30.xi.1922, 1 ♀.

As stated in my revision, this can hardly be Erichson's *Culex australis*, as the hind tibiae have no trace of a white spot at the tip. It therefore seems best to rename it. The present specimen is the first to be recorded from Tasmania.

***Aëdes (Ochlerotatus) luteifemur*, sp. n.**

♀. Head with the usual light ochreous narrow scales above. Upright scales mostly yellowish. Proboscis dark, but with rather numerous ochreous scales at the sides and beneath about the middle. Palpi one-sixth as long as the proboscis, dark brown, with some scattered pale scales, especially at the tip. Thorax with the

integument uniformly reddish; mesonotal scales mostly golden, irregularly mixed with some black ones; bristles black. Anterior and posterior pronotal lobes with rather broad whitish scales below, narrower dark brown ones above. Pleurae with small patches of white scales. Three or four strong dark lower mesepimeral bristles. *Abdomen* with the first few tergites clothed mostly with dark purplish scales, the last three or four light buff, the colours gradually shading off and differing in relative amounts in different specimens; in the lightest specimen the buff colour extends over practically the whole dorsum of the abdomen. Sternites with whitish scales only; small inconspicuous white patches at the basal lateral corners of each tergite. Cerci long, black. *Legs* mainly dark; the four anterior femora mottled with light and dark scales in front, paler behind; hind femora almost entirely ochreous, only a few dark scales on the upper surface towards the apex. No distinct mottling on tibiae or tarsi, nor any trace of a pale spot at the tip of the hind tibia, but in some specimens there are aggregations of a few pale scales at the bases of the second and third segments of the hind tarsi, giving a slight suggestion of banding. All claws toothed. *Wings* with the scales of the basal half dark brown, those of the apical half rather lighter; outstanding scales narrow. Cross-veins separated by less than the length of the posterior. Wing-length, 5-6 mm.

TASMANIA: Advent Bay, 24.xii.1922, type ♀; Strahan, 6.ii.1923, 2 ♀; Mt. Farrel, 8.ii.1923, 1 ♀. VICTORIA: Lower Tarwin, xi.1925, 4 ♀ (G. F. Hill).

This seems rather well distinguished from the other species of the subgenus with dark tarsi by the entirely ochreous hind femora.

### ***Aëdes (Ochlerotatus) purpuriventris*, sp. n.**

♀. *Head* with narrow ochreous scales above; proboscis purplish black; palpi similarly coloured, one-sixth as long as the proboscis. *Thorax* dark brown; mesonotal scales and bristles mostly dark brown; a few lighter scales round the front margin, as well as on the scutellum. Anterior pronotal lobes with rather dense, broad and flat light brown scales. Posterior pronotal lobes with flat white scales below, narrow dark ones above. Three dark lower mesepimeral bristles. Pleurae with patches of creamy-white scales. *Abdomen* dark purple-scaled above and below, except on the first segment, where the scales are white, and on the last segment, where they are light ochreous. Cerci long, black. *Legs* dark purplish, without any mottling; under sides of anterior femora light; hind femora with the basal half or rather more whitish, except for a dark dorsal line reaching almost to the base, outer half dark. All claws toothed. *Wings* with dense dark scales, outstanding ones long and ligulate. Membrane in the middle of the wing somewhat darkened. Wing-length 5 mm.

TASMANIA: Eaglehawk N., 23.xi.1922, 1 ♀.

This is perhaps most nearly allied to *A. burpengaryensis* (Theo.), from which, however, it differs rather conspicuously in the purple-scaled venter and the dark outer half of the anterior surface of the hind femora. It is just possible that it may be the female of *A. nigrithorax* (Mcq.).

### ***Aëdes (Pseudoskusea) concolor* (Taylor).**

TASMANIA: Eaglehawk N., xi.1922, 3 ♂ 3 ♀ bred.

This species has previously been reported only from New South Wales. Now that it has been found also in Tasmania my suggestion that it might be simply a geographical form of the Tasmanian *A. crucians* (Walk.) appears improbable.

**Aedes (Finlaya) alboannulatus** (Macq.).

VICTORIA: Fern Tree Gully, 25.x.1921, 1 ♀. TASMANIA: Strahan, 5.ii.1923, 2 ♀.

Not previously known from Tasmania.

**Culex fatigans**, Wied.

NEW SOUTH WALES: Mt. Wilson; Wentworth Fall; Woy-Woy; Killara.

**Culex fergusonii** (Taylor).

NEW SOUTH WALES: Woy-Woy, xi.1921, 1 ♀.

The wings are rather scantily scaled, and there are two brownish clouds on the membrane, one in the end of the upper basal cell, extending up towards the costa, and the other, smaller, in the base of the fork of the fifth vein.

**Culex (Lophoceratomyia) fraudatrix**, Theo., var. **annulata** (Taylor).

NEW SOUTH WALES: Woy-Woy, xi.1921, 1 ♂ 1 ♀; Waterfall, xi.1921, 1 ♀.

The hypopygium is the same as in typical *C. fraudatrix*, and the antennae are also similar, except that the scale-tuft on the sixth segment is very much smaller.

## VI.—SOME CULICINE LARVAE AND OTHER RECORDS FROM SINGAPORE.

Included in small collections received during 1925 and 1926 from Surgeon-Commander D. H. C. Given, of the Naval Base, Singapore, are a number of interesting specimens. Among these are a new species of *Armigeres*, reared from pitcher-plants, and several larvae which have not hitherto been described.

**Megarhinus acaudatus**, Leic. (fig. 3, a).

This has already been recorded as breeding in pitcher-plants in Singapore, and was found again by Dr. Given. According to him the larvae are always found singly in the pitchers, and if several are put together they start eating one another. They show hardly any difference from those of other species of the genus, all of which so

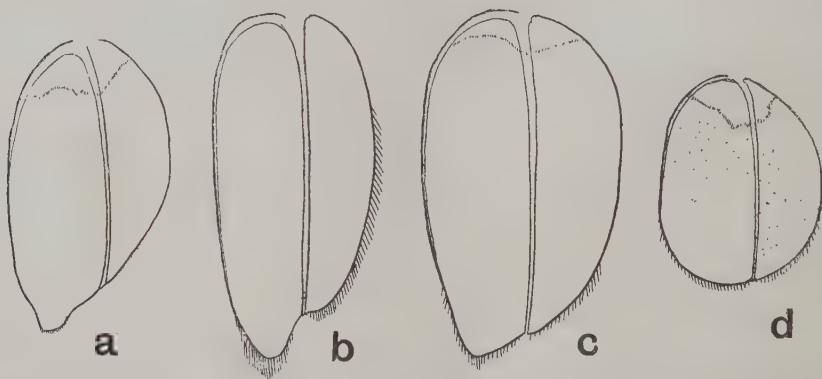


Fig. 3. Pupal paddles of Oriental species of *Megarhinus* (all to same scale): (a) *M. acaudatus*, Leic.; (b) *M. leicesteri*, Theo.; (c) *M. magnificus*, Leic.; (d) *M. quasiferrox*, Leic.

far as known are remarkably uniform in nearly all structural details. In the two specimens sent the head is uniformly dark brown; the siphon short, under  $2 \times 1$ , rather light brown in colour, and only slightly tapering towards the tip. Larvae of *M. splendens*, Wied., and *M. quasiferox*, Leic., also have a uniformly dark head, but according to British Museum specimens the siphon is much darker in colour and distinctly more tapering than in *M. acaudatus*. *M. leicesteri*, Theo., is more noticeably different; in this species the head is yellow, with broad dark brown lateral and posterior margins to the clypeus; the siphon is much larger and also somewhat longer relatively to its breadth at the base (fully  $2 \times 1$ )

The pupa of *M. acaudatus* has paddles of a rather distinctive shape, intermediate between those of *M. splendens* or *M. quasiferox* and *M. leicesteri*, a point which is of some interest since the adult occupies a similar intermediate position. In *M. magnificus*, Leic., the paddles are very much like those of *M. acaudatus*, but rather less pointed. The accompanying figures will explain the differences between the pupal paddles of these species. It will be noticed that *M. acaudatus* (fig. 3, a) resembles *M. quasiferox* (fig. 3, d) and *M. magnificus* (fig. 3, c) in having an irregular black transverse line near the base, but differs from these species as well as from *M. leicesteri* (fig. 3, b) in the rudimentary fringe.

#### **Uranotaenia brevirostris**, Edw. (fig. 4, a).

Larvae of this species were obtained by Dr. Given from pitcher-plants. He states that the larva "remains under water most of the time and uses its siphon, like other pitcher-plant larvae, for anchoring itself to the side of the pitcher. When feeding it has a peculiar crawling movement along the bottom, like a dog on a scent." The head, siphon and anal segment are heavily chitinised and black, the thorax and abdomen creamy-yellow.

Head longer than broad, rather shortly oval in shape; frontal hairs not spiniform, crowded towards the front and arranged in a very unusual manner (fig. 4); the

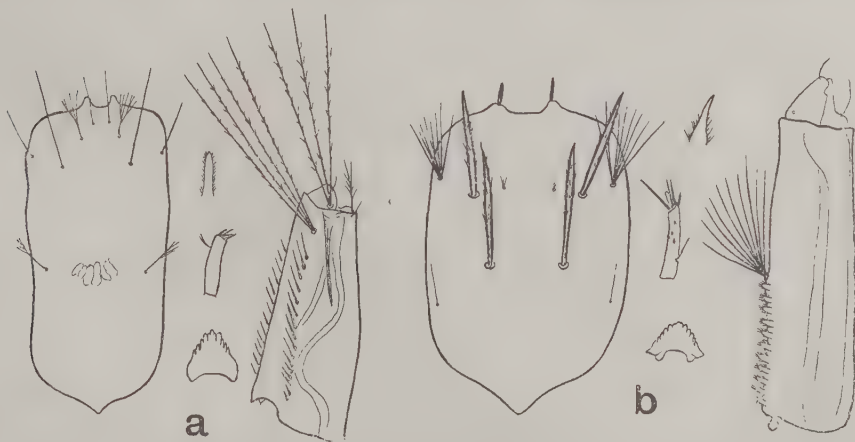


Fig. 4. Clypeus, antenna, mentum, siphon and comb-scale of larva of: (a) *Uranotaenia brevirostris*, Edw., and (b) *U. subnormalis*, Mart.

anterior pair very close together; outermost pair simple. Clypeal spines absent. Antennae very short, only about four times as long as broad; in shape nearly cylindrical, slightly curved; tuft small, subapical; apical bristles and papillae short, only a quarter as long as the antenna. Mentum of rather unusual form: one



large blunt central tooth, bearing a pair of smaller denticles, and on each side only four moderately large teeth. Abdominal hairs nearly all single; two long lateral ones on the first segment, one on the second and third. Lateral plate on the eighth segment not strongly chitinated, with a row of about 10 long but rather blunt teeth on its posterior margin. Anal segment about as long as broad, with a few short spines in the middle posteriorly. Siphon about 2.5–3 times as long as broad. Pecten with about 16 teeth, these slightly and evenly fringed on both sides as usual, but long and pointed, the row extending almost the entire length of the siphon. Siphonal tuft large, composed of 4 plumose branches, and placed close to the tip of the siphon; a second large tuft of 3 plumose branches arises from each anterior valve, and the posterior valves have each a long plumose hair. This siphonal structure is quite unlike that hitherto found in any other species of the genus. The other pitcher-plant species of this genus (*U. ascidiicola*, Meij., and *U. xanthomelana*, Edw.) also have very peculiar larvae, but are quite different from *U. brevirostris*.

***Uranotaenia subnormalis*, Mart. (*roperi*, Edw.) (fig. 4, b).**

Larvae of this species, hitherto undescribed, closely resemble those of typical members of the genus, such as *U. geometrica*, Lynch, *U. balfouri*, Theo., and others. The head is rounded; the four main frontal hairs very stout and flattened, also somewhat pubescent. Outermost frontal hair with 5–7 branches; posterior hair simple. Clypeal spines present as usual. Antenna with an unbranched hair near the base; terminal bristles rather long, the longest fully half as long as the antenna. Mentum with the central tooth broad and indistinctly trilobed. Comb-teeth of eighth segment sharply pointed and fringed towards the base only. Siphon  $4 \times 1$ ; tuft placed in the middle and composed of about 10 simple hairs. Pecten teeth 10–12, broad and scale-like, pale in colour, conspicuously fringed all round. Anal gills almost as long as the siphon, pointed.

***Rachionotomyia aranoi*es, Theo. (fig. 5, a).**

This has been reared from pitcher-plants on several occasions, and the larvae have been described by de Meijere under the name *Ficalbia tenax*. The following diagnostic points may be noted from specimens obtained by Dr. Given at Singapore, where it is by far the commonest pitcher-plant mosquito.

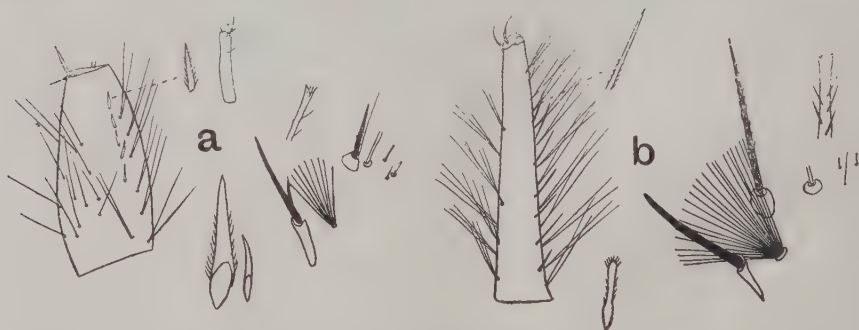


Fig. 5. Details of larval structure of (a) *Rachionotomyia aranoi*es, Theo., and (b) *R. nepenthis*, Edw.: siphon,  $\times 50$ ; enlarged pecten tooth and comb scale; the two spines and bases of adjacent hairs on thorax,  $\times 50$ ; tip of one of the branches of a thoracic hair-tuft, much enlarged; and antenna of *R. aranoi*es,  $\times 50$ .

The main hair-tufts of the thorax have each about 15, those of the abdomen about 10 branches; the individual hairs in these tufts are only slightly barbed, but their tips are in most cases split into 4–6 points. The spine on the mesothorax is shorter

than that on the metathorax and is accompanied by a fine hair ; spine on metathorax accompanied by a second spine about half the length of the larger one. Siphon  $3 \times 1$ , almost uniformly pale in colour ; a group of single hairs on the dorsal surface, and two irregular rows of double hairs on the ventral surface. Pecten teeth about 5 in number, the first well removed from the base of the siphon, evenly fringed. Eighth segment with a slightly chitinated plate to which the comb is attached ; comb teeth about 6-10 in number, sharp-pointed, some long and some short, irregularly alternating, the longer ones slightly fringed. Posterior margin of anal saddle with about 6 rather stout spines ; lateral hair of saddle long and single ; on the ventral membrane of the anal segment, between the arms of the saddle, is a pair of short hairs, each forked from the base.

The British Museum also possesses larvae of this species taken in bamboos in Ceylon (*E. E. Green*). These differ in several details from the Singapore specimens : the meso- and metathoracic spines are of equal length ; the siphon is dark, especially beyond the middle, and its dorsal hairs are either double, or in a few cases triple ; the lateral hair of the anal segment is double ; the ventral hair has 4-6 branches ; and the spines on the margin of the saddle are 10-12 in number and more slender. Another larva from Kuala Lumpur (*Dr. A. T. Stanton*) is similar to the Ceylon larvae, but has a longer siphon ( $4 \times 1$ ) and the lateral hair of the anal segment is triple. No differences are discoverable between the adults from these three sources, but it seems possible that the larval differences may indicate that the species is in process of segregation into two races, one inhabiting bamboos and the other pitcher-plants.

#### ***Rachionotomyia nepenthis*, Edw. (fig. 5, b).**

In company with larvae of *R. aranoioides* in pitchers Dr. Given also obtained a few *R. nepenthis*. Although the adults of these two species are very much alike, there are pronounced differences in the larvae. The principal features distinguishing *R. nepenthis* are as follows :—

Main hair-tufts of thorax each with about 35, those of the abdomen each with about 20 branches ; the individual hairs are stouter than those of *R. aranoioides*, more distinctly plumose, and generally only bifid or trifid at the tip. Spine on mesothorax longer than that on metathorax, slightly plumose and without accompanying hair ; no accessory spine on metathorax. Siphon quite  $6 \times 1$  ; hairs on dorsal surface triple ; those on ventral surface double but longer than in *R. aranoioides*. Pecten teeth very long, slightly fringed towards the base only ; about 7 in number, the first near the base of the siphon. Eighth segment without plate. Teeth in comb about 16 in number, arranged in a close-set regular row ; those nearest the siphon are large, the others gradually diminishing in size towards the anal segment. The subventral hair of the anal segment has about 10 branches.

#### ***Orthopodomyia maculipes*, Theo. (fig. 6, a).**

Up to the present this species has been recorded only from the Andaman Islands, but specimens were obtained in a tree-hole in Singapore by Dr. Given. In my synopsis of Oriental Culicines I suggested that the three described Oriental species of *Orthopodomyia* might be nothing more than colour varieties. This, however, is probably not the case, since larval skins of *O. maculipes* sent by Dr. Given show very marked differences from a larva of *O. albipes*, Leic., in the British Museum from Ginting Simpah, Malay Peninsula (*Dr. A. T. Stanton*). Larvae of *Orthopodomyia* from all parts of the world are similar in appearance, but the differences between

these two are as great as between any two species of the genus. The diagnostic points are as follows :—

*O. maculipes*, Theo. (fig. 6, *a*) (fourth stage larva). Antennae entirely black and rather stout, 5.5 times as long as their greatest breadth. Head nearly all black, but with a rather large clear space on each side surrounding the eye. Abdominal plates, anal segment and siphon almost entirely black, only the extreme tip of the



Fig. 6. Antenna and comb-scale of larva of (*a*) *Orthopodomys maculipes*, Theo., and (*b*) *O. albipes*, Leic.; (*c*) appendages of lobe of side-piece of *Culex* (*Lophoceratomyia*) *navalis*, sp. n.

last-named yellowish. Comb-teeth with a strong fan-like fringe at the tip, the central tooth not or hardly distinguishable. Siphon moderately tapering, index 3.3, base 2.3 times as broad as the tip; tuft only just before the middle. The third-stage larva is similar except for the absence of the abdominal plates and the shorter siphon (2.5×1).

*O. albipes*, Leic. (fig. 6, *b*). Antennae dark brown, slender, 8 times as long as broad and strongly tapering towards the tip. Head light brownish, as are the abdominal plates and anal segment. Comb-teeth sharply pointed, with fine fringe in the middle only. Siphon dark brown, extreme tip yellowish, shape strongly tapering; index 5.5; base 3 times as broad as the tip.

#### ***Armigeres giveni*, sp. n.**

♂. *Head* black-scaled, with a narrow white border and a small occipital spot. Clypeus bare. Proboscis rather shorter than usual. *Thorax* black-scaled dorsally; a narrow white margin to the mesonotum, composed of narrow scales except just in front of the wings, where they are broad and flat. One lower mesepimeral bristle. *Abdomen* black-scaled dorsally, tergites with white lateral patches, the first two or three fused, the rest rounded and not visible from above. Sternites 1-6 all white, 7 black. *Hypopygium*: Side-pieces over twice as long as broad; basal lobe small, provided with two blunt stiff bristles set on small tubercles. Claspers rather short, only half as long as the side-pieces, very little curved and slightly constricted in the middle, with 12 longish teeth on the distal half. *Legs* normal; hind femur white to the tip on the outer side; hind tibiae longer than the middle ones. *Wings* normal.

Length of body, 4.2 mm.; wing, 3.8 mm.

*Larva*.—Closely resembles those of other members of the genus. The number of branches in the dorso-lateral tufts of the first five abdominal segments are respectively 10, 7, 4, 4, 2; this seems to indicate a slight increase in hairiness as compared with *A. obturbans*, in which the numbers are 7-10, 5-7, 2-3, 2, 2, the tuft of the fourth segment apparently never being more than double. Comb-teeth 6-7 (as against 10-14 in *A. obturbans*). Siphonal index about 1.8. Gills short, hardly longer than the anal segment. Length, 8 mm.

MALAY PENINSULA: Singapore (Dr. D. H. C. Given); described from two males reared from larvae found in pitcher-plants, and one whole larva from the same batch.

This new species is most closely allied to *A. kuchingensis*, Edw., from which it differs chiefly in details of the hypopygium, the side-pieces being longer and the claspers shorter and less curved, with fewer teeth, while the basal lobe has only two instead of three bristles.

***Aëdes amesi* (Ludl.) (*Stegomyia fusca*, Leic.) (fig. 7, a).**

Larvae of this species were found by Dr. Given in water collected in the hollows of a fallen tree in the mangrove area. Two lots were obtained, from each of which one skin was preserved. The two skins are similar, and there can be little doubt that they are correctly determined.

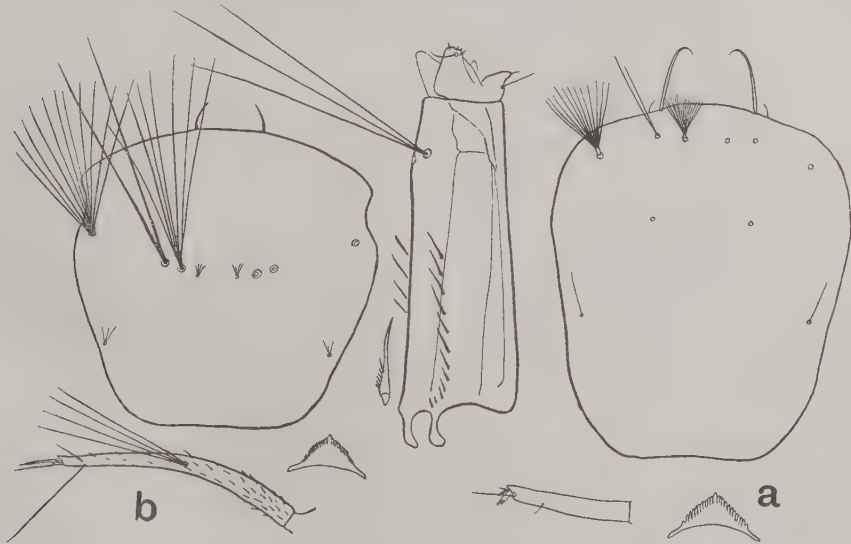


Fig. 7. Clypeus, antenna and mentum of (a) *Aëdes amesi*, Ludl., and (b) *A. longirostris*, Leic.; in middle, siphon and pecten tooth of *A. longirostris*.

Head dark in colour and rather rounded in shape, not much broader than long. Antennae short, cylindrical, with a single fine hair on the shaft, which is placed much beyond the middle; apical bristles and papilla as in *Stegomyia*. Arrangement of hairs on dorsal surface of head exactly as in *Stegomyia*, three pairs being placed in a curved line close to the front margin of the clypeus; of these the inner pair is small and has about 15-18 branches, the middle pair is much longer and is forked at some distance from the base, and the outer pair is also rather long, with about 12 branches. Clypeal spines long and curved; external to them is a short hair, again as in *Stegomyia*. Mentum with the teeth rather long, about 12 on each side of the



middle. No spine associated with the metathoracic tuft. Dorsal abdominal hairs inconspicuous. Comb consisting of 50 or more almost needle-like bare teeth in a triangular patch. Anal segment with small saddle; gills about as long as the saddle, with rounded tips; 5-7 tufts in the brush, none before it. Siphon dark; index under 2; no acus. Pecten consisting of about 8-12 evenly-spaced rather slender teeth with a few denticles on one side towards the base; a long single hair (sometimes a double hair, according to the collector) immediately beyond the pecten and hardly beyond the middle of the siphon.

Except for the shorter anal gills and the presence of very numerous small comb-scales in a patch, the larva is strikingly similar to *A. albopictus* and other members of the subgenus *Stegomyia*. The outer anterior frontal hair has more branches than in *A. albopictus* (12 instead of 3-4).

### ***Aedes longirostris* (Leic.) (fig. 7, b).**

Specimens of this species were also obtained from larvae from the mangrove area. Adults, especially females, are very similar in appearance to *A. amesi*, the most conspicuous differences being the longer proboscis in both sexes and the short palpi of the male. I have previously suggested that both might be referred to the subgenus *Skusea*, but if the larvae sent by Dr. Given have been correctly associated with the adults, which there seems no reason to doubt, the two are evidently not nearly related. The species was obtained on several occasions, and no other adults were reared to which these larvae could be referred. They may be described briefly as follows:—

Head very broad and rather light in colour. Antennae long, curved and tapering, surface with numerous spicules, especially towards the base; tuft of three or four long hairs placed a little before the middle; a long fine hair near the tip. Frontal hairs placed close together and far back, the arrangement being practically the same as in *Aedes cinereus*, Mg.; the three main pairs of tufts very long, consisting respectively of 10-12, 2 and 6-7 hairs. Mentum with about 12-14 teeth on each side of the stronger median tooth. Abdominal hairs inconspicuous. Comb consisting of about 40 small narrow bare teeth in a patch. Anal segment with small saddle which is covered with small spicules; lateral hair single and rather long; about 8 tufts in the brush, none before it. Siphon not very dark; index about 3.5; well-developed acus at base; pecten reaching just beyond the middle, with about 12 spines, none detached; tuft of 3 very long hairs, placed far beyond the pecten and only a little before the tip of the siphon. Valves normal.

### ***Culex spathifurca*, Edw.**

Specimens of this mosquito were reared on two occasions from larvae found in pots of pure urine placed as traps, no other species occurring.

*Larva*.—Head without extensive dark markings, but darker behind and with a small transverse dark mark on each side of the clypeus just in front of the small posterior hair. Antennae moderately long, pale in colour; tuft large and placed at two-thirds; subapical bristles near the tip. Main frontal hairs close together, plumose, and in threes, the outer very little in front of the inner; the small median pair simple and placed far forward. Comb of about 40 small narrow scales, bluntly pointed and shortly and evenly fringed. Anal segment ringed; gills very long and stout, nearly three times as long as the anal segment, tips rounded; about 8 tufts in the brush, none piercing the ring. Siphon about  $6.5 \times 1$ , with short but broad acus. Pecten of 12 teeth, extending one-fourth the length of the siphon; teeth each with about four large denticles, the last near the tip of the tooth. Three lateroventral pairs of single hairs which are about equal to the diameter of the siphon in length, the first well beyond the pecten; apparently no ventral tufts or hairs.

***Culex nigropunctatus*, nom. n.**

*Culex pullus*, Edw. nec Theo. ; *Culiciomyia annulata*, Theo.

In describing *Culex muticus* from New Britain (Bull. Ent. Res. xiv, 1923, p. 7) I remarked that the supposed new species might in fact be the same as Theobald's *C. pullus* from New Guinea, and that my previous identification of *C. pullus* with the Oriental *Culiciomyia annulata*, Theo., might be erroneous. Since then I have examined material of *C. muticus* from Ambon, Amboina, and from Pionnierbivak, Mamberano and Merauke, Dutch New Guinea (*Dr. S. L. Brug*). This fresh material makes it highly probable that *C. muticus* is in fact the same as *C. pullus*, and since the name *annulata* is preoccupied, I propose for the Oriental form the new name *nigropunctatus*.

Larvae from Singapore exhibit the following features: Head extensively dark, especially on the underside. Antennae stout and pale on the basal two-thirds, slender and dark on the third beyond the tuft; subapical bristles black and not far from the tip. The outer of the two main frontal hairs with two branches, placed well in front of the inner, which has four branches; the small median hairs very short, bifurcate, and placed almost in a line with the outer pair. Comb of 6 large sharply-pointed teeth in a rather regular row. Anal segment ringed; gills moderate, nearly twice as long as the ring; about 10-12 tufts in the brush, none piercing the ring. Siphon about 6×1, evenly tapering, with short broad acus ending in a long point at each side. Pecten with about 10-12 teeth, evenly spaced and reaching a little more than one-third the length of the siphon; last two or three teeth considerably larger; each with a number of fine pale denticles towards the base. Tufts arranged in 5-6 ventral and 2 lateral pairs, all beyond the pecten, each with 4-6 branches, the longest about twice as long as the diameter of the siphon.

***Culex (Lophoceratomyia) navalis*, sp. n. (fig. 6, c).**

Closely allied to *C. minor*, Leic., the antennae having the same structure, but differs as follows: Palpi of the same length as the proboscis, instead of longer than the proboscis by the length of their last segment. Side-piece of hypopygium with only one or two longish hairs at the base beneath, instead of a row of 6-8. Appendages of lobe as figured, the leaf very small and short. Aedeagus as figured by Barraud for *L. minor*.

MALAY PENINSULA: Singapore (*Dr. D. H. C. Given*), 1♂ 1♀ reared from pitcher-plants.

*Larva*(?).—(A) Antennae entirely pale, not very slender; tuft at three-fifths; the two subapical hairs placed practically at the tip, of moderate length, equalling the longer of the two apical hairs. Mentum of unusual form, the outermost tooth on each side being widely detached. Skin of thorax and abdomen bare, without fine shagreen. Siphon about 7×1, tapering on the basal part, end half nearly parallel-sided. Pecten with about 8 teeth, long and slender, finely fringed on the greater part of their length, but the base without strong denticles. Six pairs of ventral tufts, the first and longest at the end of the pecten and about three times as long as the diameter of the siphon. Anal brush with five tufts; gills very long, slender and pointed, almost four times as long as the anal segment. Numerous narrow fringed scales in the comb.

(B) A second larva differs in several respects. Antennal tuft at three-quarters; mentum without detached lateral tooth; siphon about 5×1; gills not much over twice as long as the anal segment.

(C) A third specimen is not unlike larva (B), but has the antennae entirely black, and the siphon also dark; mentum with two or three outer teeth more or less detached. All these larvae are whole specimens, not isolated skins; it is,

therefore, uncertain whether they represent distinct species and whether any of them belongs to the species under discussion.

Larvae of *C. minor*, Leic., reared from bamboos in the Malay Peninsula (*Dr. H. P. Hacker*) are quite different from any of those described above. They have the apical part of the antenna dark; tuft at three-quarters; subapical hairs distinctly removed from the tip, and over twice as long as the longer apical hair; mentum normal; siphon about  $10 \times 1$ , with three pairs of rather small lateral tufts, the first far beyond the pecten; teeth of pecten about 12 in number, with strong denticles; gills about three times as long as the anal segment.

## VII. ON *ANOPHELES IMPLEXUS*, THEO., WITH OTHER RECORDS FROM KATANGA, BELGIAN CONGO.

The following records are based on collections received in 1925 and 1926 from Dr. J. Schwetz, who in organising the new Institute of Veterinary Research at Elizabethville, has taken the opportunity to make a survey of the blood-sucking insects of the Katanga province. The mosquito fauna of this interesting region of the Congo has not hitherto been studied in detail, and it was therefore to be expected that some new discoveries would be made; this proved to be the case in the first collections received, which contained examples of a new *Stegomyia*. Of even greater interest was the subsequent discovery of the breeding-places of *Anopheles implexus*. The dominant species at Elizabethville appear to be such typically West African insects as *Culex duttoni* and *C. nebulosus*, but the fauna also includes a number of Central and East African forms.

### **Anopheles implexus**, Theo. (figs. 8-10).

This remarkable species has hitherto been recorded only from Uganda, where it has been found at various localities near the shores of Lake Victoria. Some unpublished records from this region are: Buanulea (*Maj. A. D. Fraser*); Budongo Forest, Unyoro, and west shores of Victoria Nyanza, Buddu (*Dr. S. A. Neave*).

Concerning its occurrence at Elizabethville Dr. Schwetz sends the following note: "In June 1925, among various mosquitos captured in a farmhouse near the Kisanga River, about 5 km. from Elisabethville, was a female *A. implexus*. In April 1926 I collected mosquitos in the same house and again captured a female *A. implexus*. As the source of these mosquitos was certainly the Kisanga River (a small clear stream running through a little forest glade), I directed my attentions there. Some natives sent to this stream captured in the daytime among other mosquitos a dozen *A. implexus*, an *A. mauritanus*, and an *Aedes wellmani*. . . . After several fruitless endeavours we found, at the edge of the stream and under the shade of trees, a sort of small spring where there were Anopheline and Culicine larvae, among others some large yellow Anophelines. These large larvae produced males and females of *A. implexus*; the duration of the pupal stage of two specimens observed in the laboratory was three days. Other larvae found in the same spring gave rise to *A. pretoriensis*."

As stated by Theobald in his description, *A. implexus* cannot possibly be confused with any other member of the genus on account of the long outstanding tufts of linear scales on each segment of the abdomen. It is the largest and most conspicuously ornamented Anopheline in the African fauna, and as it has never been figured we take this opportunity of supplying the deficiency.

Two or three striking peculiarities are not clearly indicated in Theobald's description: (1) The female palpi have a rather peculiar "knotted" appearance, owing to the black scales at the tips of the first two segments being suberect, whereas



the white scales at the bases of segments 2 and 3 are appressed, the black scales just beyond these being again suberect; (2) the pleurae are marked with conspicuous black patches separated by white lines; (3) on each abdominal sternite except the last there is a pair of large rounded white spots on the integument, in addition to a small white spot on the lateral margin of each tergite near the base. These points are clearly shown in fig. 8, *b* and *d*. The Katanga specimens are quite similar to those from Uganda, except that most of them have a more or less extensive yellow area in the middle of the third vein, all the Uganda specimens having this vein entirely dark.

Apart from the usual sexual differences, the male is very similar to the female, but it lacks the conspicuous tuft of black scales on the second segment of the antenna, and the yellow markings on the wing are proportionately more extensive. The hypopygium (fig. 10, *a*, *b*) is of the *Anopheles* type, except that there is only a single basal spine to the side-piece placed on a strong tubercle; in addition to this the

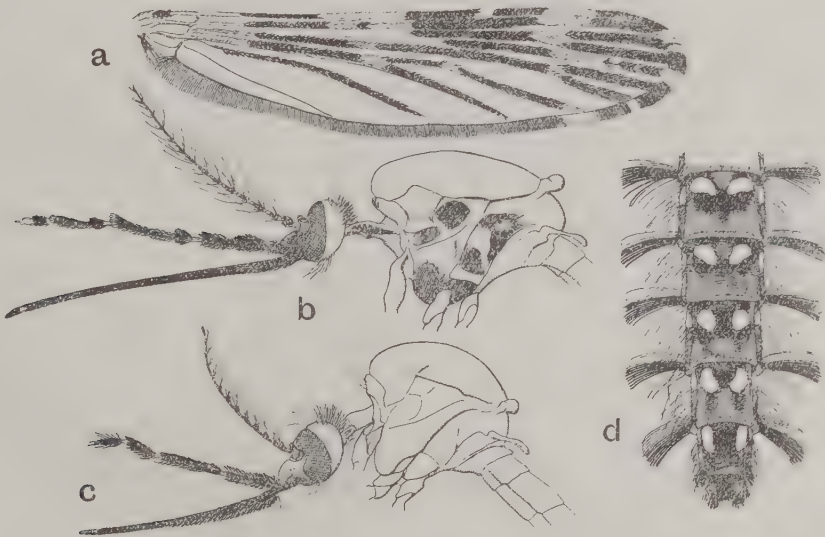


Fig. 8. *Anopheles implexus*, Theo., ♀: *a*, wing; *b*, side view of head and thorax; *d*, underside of abdomen; *c*, head and thorax of *Chagasia fajardoi*, Neiva.

side-piece has only one bristly spine on the inner margin at about mid-length. Clasper moderately stout and of even width throughout. Claspette divided into two small lobes, the inner with one slender hair and one stouter bristle, outwardly placed, the outer with two spines which are curved and almost fused, forming a slender club. Mesosome of the usual type, with four pairs of black leaflets, the longest about half as long as the body of the organ. Ninth tergite with the lateral lobes large and broad.

Christophers in his recent catalogue of the ANOPHELINI suggested that *A. implexus* might prove to be related to the South American *A. (Chagasia) fajardoi*. The discovery of the male, however, proves that this is certainly not the case. In the possession of only a single basal spine on the side-piece, the hypopygium resembles those of the American species placed by Christophers in the subgenus *Nyssorhynchus*. But there is no reason on this account to assume relationship with these American species, since *A. algeriensis*, one of the typical European members of the subgenus *Anopheles*,



also has a single basal spine. In the shape of the thorax and the structure of the neck and antennae, *A. implexus* is a typical *Anopheles* and shows no approach to *Chagasia* in these structures any more than it does in the hypopygium. As shown in the accompanying figure (fig. 8, c) the hairs at the bases of the antennal segments of the female occur on the upper side only in *A. (C.) fajardoi* instead of all round as in other *Anopheles*. Further, in each of the three specimens examined the neck is long and bent down in a peculiar manner so that the head lies close above the front coxae. These and other peculiarities clearly mark off *A. fajardoi* as belonging to a distinct subgenus or genus.

The pupa of *A. implexus* (fig. 9) is chiefly remarkable for the great development of the median dorsal keel on the posterior part of the thorax, which here forms a

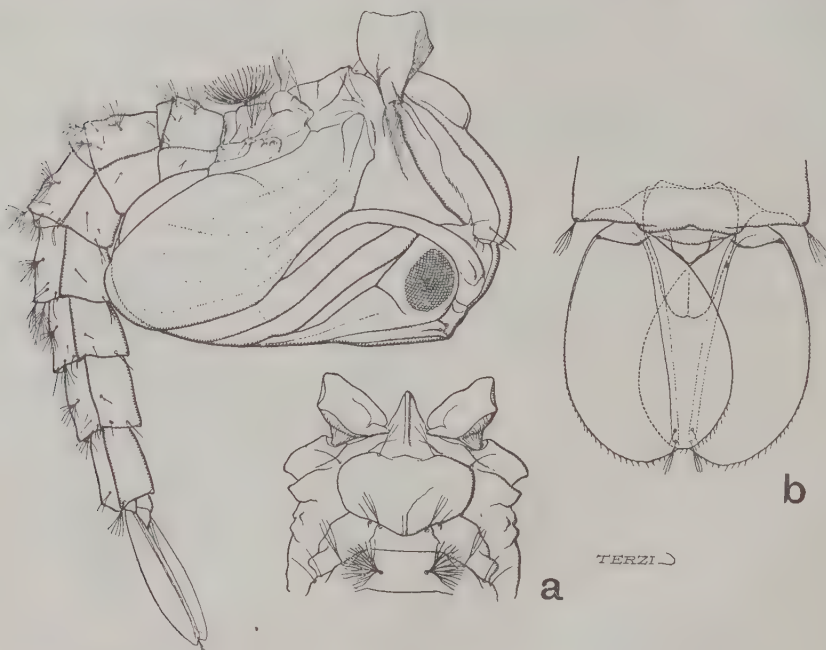


Fig. 9. Pupa of *Anopheles implexus*, Theo.: a, dorsum of thorax; b, paddles.

conspicuous crest. There is also a large flattened area immediately below the insertion of the respiratory trumpets, which are unusually broad and widely open. The hair-tufts at the posterior lateral corners of the last abdominal segment are small and composed of four or five hairs; the apical hair of the paddle is very short and split into two or three simple straight branches.

*Larva*.—Pale in colour; head practically without dark markings except for a small spot in front of the eye, and sometimes small spots at the insertion of the posterior frontal hairs. Median anterior clypeal hairs simple, placed rather close together. External clypeal hairs with simple stem, about one-third the length of the hair, outer part with about eight irregular branches. Posterior clypeal hair short and simple. Plumose frontal hairs well developed. Antennae (fig. 10, c) of moderate length, rather stout and somewhat tapering; a large plumose hair placed a little before the middle and reaching to the tip of the antenna; apical hair branched. Thorax with the plumose hairs normal in size and arrangement. Innermost

shoulder-hair plumose, but much shorter than the one next to it. No float-hair on metathorax. *Abdomen* with normal plumose lateral hairs on segments 1-6. No float-hairs on 1, 2 or 7, the corresponding hairs on these segments having simple filiform branches. Float hairs on 3, 4 and 5 large (fig. 10, *e*) each composed of about

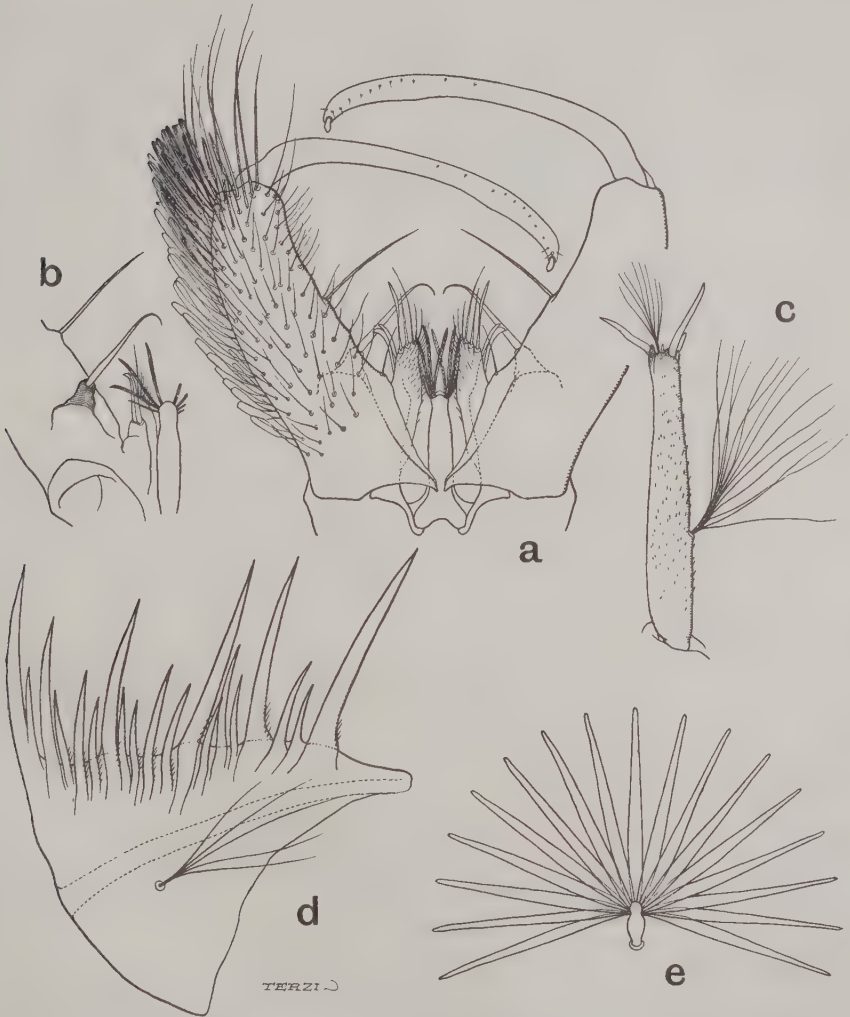


Fig. 10. *Anopheles implexus*, Theo.: *a*, male hypopygium from above; *b*, basal parts of hypopygium from below; *c*, antenna; *d*, comb; *e*, float-hair of larva.

18 leaflets, which are long, narrow, rather bluntly pointed, with unbroken margin. Float-hairs on segment 6 similar to the other three pairs, but with fewer leaflets. Comb (fig. 10, *d*) with about five very long teeth, between which are altogether about 10 short ones; both long and short teeth are quite simple, without smaller

serrations. The dorsal intersegmental plates are small, occupying not more than one-third of the width of the abdomen. Gills long, fully half as long again as the anal segment.

**Anopheles kingi**, Chr.

This interesting species was described by Christophers in 1923 from a few examples taken in the Livingstone Range, Kenya Colony, by Mr. H. H. King. Numerous specimens were obtained by Dr. Schwetz at Kalunga, 23.x.1925, at an altitude of about 6,000 ft. The 17 females examined show a certain amount of variation. The third segment of the hind tarsi sometimes has the tip rather broadly white, as described by Christophers, but in the majority of specimens this segment is entirely dark. The fifth hind tarsal segment is entirely black in all. The size of the pale areas on the wing varies a little, and the small pale spot before the middle of the wing sometimes reaches the costa.

**Anopheles distinctus**, N. & C.

A female of this species was taken at Kalunga in company with *A. kingi*, which it somewhat resembles in its four-ringed palpi and the reduction of the pale costal spots. Since it was described (from N.-E. Rhodesia) it does not seem to have been met with again until now.

**Anopheles wellcomei**, Theo.

Several specimens of this little-known species were taken at Kivele, vi.1925. The number and extent of the dark markings on the wing-field are rather variable, and in some examples the costa is nearly all dark, the pale area above the stem of the upper fork-cell being absent. This is also the case in a specimen in the British Museum from Angola.

**Anopheles theileri**, Edw.

One specimen taken in house, Elisabethville, v.1926. The small subapical dark spot on the costa, and some of the dark areas on the other veins are larger than in Theobald's type of *Pyretophorus albipes*, but all the diagnostic features mentioned by Christophers in his key are clearly present.

**Anopheles maculipalpis**, Giles.

Larvae of this species were found living in association with *A. implexus*. The specimens sent agree with the description recently given of larvae of this species by MacGregor (Rept. on Anophelinae of Mauritius, 1924), the reduced float-hairs being distinctive. The pupae closely resemble those of *A. pretoriensis* (Ingram & Macfie, Bull. Ent. Res. x, p. 60, 1919).

**Uranotaenia inornata**, Theo.

In my synopsis of African Culicines (1912) I gave *U. inornata*, Theo., as a synonym of *U. fusca*, Theo. Fresh material received since then has shown that this was probably an error. In the present species the scales of the pleurae are always light brown, not blue as stated by Theobald for *U. fusca*, and further, the pleural integument and the posterior pronotal lobes in *U. inornata* are largely dark brown, in *U. fusca* entirely light ochreous. Specimens of *U. inornata* were captured by Dr. Schwetz at Elisabethville; others are in the British Museum from Kokbwa, Anglo-Egyptian Sudan (*H. H. King*).

**Aedes (Stegomyia) schwetzi**, sp. n.

Closely allied to *A. (S.) apicoargenteus*, Theo., differing as follows :—

Scales around the bare ante-scutellar space all yellowish, and tending to coalesce with the short sublateral yellowish lines to form a W-shaped mark. Lateral lobes of scutellum with white scales. Abdominal tergites 2-8 (♂) or 3-8 (♀) with large median basal metallic silvery spots. Hind tibiae black at the base beneath, though with a white patch on the outer side some distance from the base, similar to that of *A. apicoargenteus*. Hind femora on the inner side with the basal third white. Fourth segment of hind tarsi entirely black, without any white scales at the base. Hypopygium similar to that of *A. apicoargenteus*, but the hairs on the projection of the basal plaque more numerous and rather longer.

BELGIAN CONGO : Elisabethville, xii.1925 (*Dr. J. Schwetz*) ; type ♂, paratype 8♂ 5♀, reared from larvae in an old tin in grass, together with *A. (S.) argenteus*. Also 12♂ 17♀, "trou a mortier (argile), près de compound."

This species (or variety) is intermediate between *A. apicoargenteus*, Theo., and *A. fraseri*, Edw., resembling the latter more closely than the former in several respects, but differing constantly in the absence of white scales beneath the base of the hind tibia, and in the entirely black-scaled terminal segment of the hind tarsi, also slightly in the hypopygium. No variation is noticeable in the series before me, but it may be noted that typical *A. apicoargenteus* have been found in Katanga by Dr. Schwetz (Kabinda, 1914). All the species of the *apicoargenteus* series are very closely related.

**Taeniorhynchus (Coquillettia) nigrithorax**, Theo.

Elisabethville and Konga, Kibara. Previously only recorded from Angola.

**Taeniorhynchus (Coquillettia) fuscopennatus**, Theo., var.

Kilwa, v.1926, numerous ♀♀. These differ from typical Uganda specimens in having the thoracic integument all yellowish, and the dark scales on the legs more numerous ; in the darkest examples the hind tibia is mainly black, with a yellow ring before the tip.

**Culex kingianus**, Edw.

A few specimens reared from larvae at Elisabethville ; they are quite similar to the type from the Sudan.

## VIII. THE CULICINE FAUNA OF NAIROBI, KENYA COLONY.

During 1924 and 1925 very large collections of mosquitos were made in and around the town of Nairobi by Drs. V. G. L. van Someren and H. S. de Boer, and submitted to the writer for determination. The Anophelines in these collections have already been reported upon by the collectors (Kenya Medical Journal, ii, no. 10, Jan. 1926), and the following notes therefore deal only with the Culicines, of which about 7,000 specimens were examined. Drs. van Someren and de Boer state that the relative abundance of the different Anopheline species varies very greatly in different years, and the same appears to be true of the Culicines. For example, *C. fatigans* was hardly represented in the 1924 collection, whereas it was the most abundant species in the 1925 collection. The subjoined list gives the names of all the species obtained, with the numbers of each present in the two collections. These numbers perhaps do not represent the true proportions of the species, as owing to an unfortunate deficiency in packing, about 3,000 specimens were destroyed in transit.



Name.	1924 Collection.	1925 Collection.
<i>Uranotaenia alba</i> , Theo. ... ..	—	1
<i>Uranotaenia mashonaensis</i> , Theo. ... ..	6	4
<i>Uranotaenia inornata</i> , Theo. ... ..	6	—
<i>Eretmopodites quinquevittatus</i> , Theo. ... ..	—	4
<i>Taeniorhynchus</i> ( <i>Coquillettidia</i> ) <i>fuscopennatus</i> , Theo. ... ..	11	—
<i>Aedes</i> ( <i>Stegomyia</i> ) <i>argenteus</i> , Poir. ... ..	470	37
<i>Aedes</i> ( <i>Stegomyia</i> ) <i>deboeri</i> , sp. n. ... ..	—	4
<i>Aedes</i> ( <i>Aedimorphus</i> ) <i>haworthi</i> , Edw. ... ..	3	1
<i>Aedes</i> ( <i>Aedimorphus</i> ) <i>lamborni</i> , Edw. ... ..	—	13
<i>Aedes</i> ( <i>Aedimorphus</i> ) <i>hirsutus</i> , Theo. ... ..	44	8
<i>Aedes</i> ( <i>Aedimorphus</i> ) <i>dentatus</i> , Theo. ... ..	13	70
<i>Aedes</i> ( <i>Aedimorphus</i> ) <i>quasiunivittatus</i> , Theo. ... ..	225	19
<i>Aedes</i> ( <i>Banksinella</i> ) <i>lineatopennis</i> , Ludl. ... ..	62	23
<i>Aedes</i> ( <i>Ochlerotatus</i> ) <i>caspicus</i> , Pall. ... ..	2	—
<i>Lutzia tigripes</i> , Grandpré ... ..	92	14
<i>Culex bitaeniorhynchus</i> , Giles ... ..	1	—
<i>Culex aurantipex</i> , Edw. ... ..	18	—
<i>Culex annulioris</i> , Theo. ... ..	611	161
<i>Culex consimilis</i> , Newst. ... ..	58	—
<i>Culex duttoni</i> , Theo. ... ..	12	—
<i>Culex theileri</i> , Theo. ( <i>tipuliformis</i> , Edw. nec Theo.) ... ..	246	285
<i>Culex univittatus</i> , Theo. ... ..	304	79
<i>Culex simpsoni</i> , Theo. ... ..	14	—
<i>Culex vansomereni</i> , sp. n. ... ..	415	148
<i>Culex pallidocephalus</i> , Theo. ... ..	10	76
<i>Culex mirificus</i> , Edw. ... ..	1	—
<i>Culex trifilatus</i> , Edw. ... ..	6	—
<i>Culex pipiens</i> , L. ... ..	805	363
<i>Culex fatigans</i> , W. ... ..	7	558
<i>Culex laurenti</i> , Newst. ... ..	261	47
<i>Culex decens</i> , Theo. ... ..	—	1
<i>Culex salisburyensis</i> , Theo. ... ..	4	25
<i>Culex rubinotus</i> , Theo. ... ..	—	2
<i>Culex</i> ( <i>Culiciomyia</i> ) <i>nebulosus</i> , Theo. ... ..	2	—

Apart from the species in this list, a few others have been recorded from Nairobi, of which *Taeniorhynchus versicolor*, Edw., and *Culex guiarti*, Blanch., are in the British Museum collection; most of the remaining names given in lists published recently by Mr. T. J. Anderson and Drs. van Someren and de Boer are synonyms or misidentifications.

The most remarkable feature of the Nairobi mosquito fauna is the number of species of *Culex*. All the known African species of the *pipiens* series are represented with the exception of *C. andersoni*, Edw., and as this is known from Kabete it is not unlikely that it will be found at Nairobi also. The *pipiens* series appears to be typically East African, in contradistinction to the *decens* series which is mainly West African. The examination of large numbers of specimens of this group has enabled me to ascertain some small differences of colouring by which the species may be distinguished without the troublesome necessity of removing and dissecting the male hypopygium.

#### ***Aedes* (*Stegomyia*) *deboeri*, sp. n.**

Closely resembles *A. (S.) poweri*, Theo., differing as follows: Small white spot on front margin of mesonotum composed mostly of narrow scales, with a few broader

ones in front. Pear-shaped spots of mesonotum rather larger; median yellow line rather broader, and the short pair of posterior lines yellow instead of white. Abdominal bands broadly interrupted, the median spots rather small on all segments. Middle femora all black in front (except for the white tip) and rather slender; middle tibiae without white at the base beneath. Ninth tergite of male hypopygium with the middle part bare; basal plaques larger, more pear-shaped.

Cotypes, 1 ♂, ix.1921 (*Dr. van Someren*); 2 ♀, 22.iv. and 12.viii.1912 (*T. J. Anderson*).

Two other damaged females appear similar to the foregoing in nearly all respects, but lack the large white patch beneath the base of the hind tibia, in which they resemble *A. masseyi*, Edw. It is possible that *A. deboeri* and *A. masseyi*, together with *A. calceatus*, Edw., *A. chaussieri*, Edw., and *A. pseudonigeria*, Theo., should be regarded as local forms of *A. poweri*.

### ***Aëdes (Aëdimorphus) lamborni*, Edw.**

Larvae of this species were obtained "from pig hole, 20.xi.1924," they are similar to those of several other known species of this subgenus. The following diagnostic points may be noted from two whole larvae mounted on a slide:—

Antennae moderately long, slightly tapering and slightly spinulose; tuft of 4-5 hairs, placed about the middle. Of the two main frontal hairs the inner has 8-9 branches, the outer is rather longer and 6-branched. Mentum with about 14 teeth on each side of the median tooth, the first 7 of which are small and close together, the rest larger and more widely spaced. Abdomen with the dorsal hairs single and inconspicuous. Siphon blackish with a yellow tip, stout, broadest a little before the middle, then strongly tapering. Pecten with 25-30 teeth which have 2-4 strong denticles towards the base; last tooth stronger but not separated from the rest; tuft of 4 hairs, placed practically at middle of siphon well beyond end of pecten. Comb of eighth segment with about 100 small scales, which are blunt-ended and finely fringed round the tip only. Anal segment short; two or three tufts before the barred area. Gills missing.

### ***Aëdes (Ochlerotatus) caspius* (Pall.).**

A specimen apparently of this species was sent by Drs. van Someren and de Boer with a preliminary instalment of the collection. If it really came from Nairobi, as labelled, the occurrence is very remarkable and difficult to explain. Neither *A. caspius*, nor its South African representative, *A. caballus* (Theo.), were subsequently obtained by the collectors.

### ***Culex consimilis* (Newst.).**

The specimens which I have determined as *C. consimilis* represent a rather distinct variety, differing from the usual West African form in the large size (which is almost equal to that of *Lutzia tigripes*) and in the possession of distinct rounded abdominal bands in both sexes. There is no obvious difference in the hypopygium.

### ***Culex vansomereni*, sp. n. (fig. 11, a-c).**

A dark-coloured member of the *pipiens* group of species, much resembling *C. pallidocephalus*, *C. andersoni* and others in appearance, but differing from all in the structure of its hypopygium, which is somewhat intermediate between the two species named.

Male palpi as in *C. pipiens*. Proboscis of female all black. Integument of thorax dark brown, pleural sutures and middle of mesepimeron paler, usually with a

greenish tint. Mesonotal scales dark brown, but a number of golden-brown ones round the front margin, and in most specimens a pair of more or less distinct patches of similarly coloured scales behind the middle. No post-spiracular scales. Abdomen very dark above, bands complete and creamy-white in both sexes, rather narrow and scarcely rounded in the female; sternites with distinct blackish apical bands, which send forward median prolongations almost to the bases of the segments. Front and middle femora white to the tips beneath; hind femora white on the basal two-thirds, with a dark dorsal line, apical third dark all round, except for the

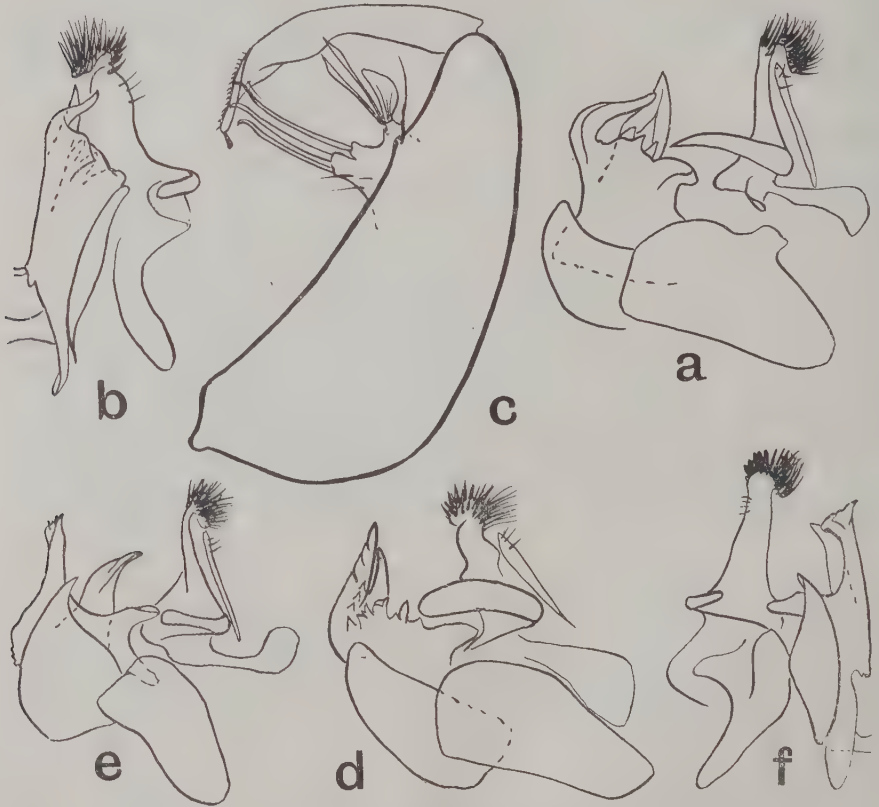


Fig. 11. Male hypopygium of (a-c) *Culex vansomereni*, sp. n.; (d) variety(?) of *C. vansomereni* approximating to *C. andersoni*; (e, f) *C. pallidocephalus* (Theo.) Edw.

conspicuous knee-spot. Hind tibiae with a large yellow spot at the tip, slightly longer than broad. Wings with normal venation and scaling. Male hypopygium as figured. Average wing-length, 4.5 mm.

Type ♂ and paratypes 14♂ 15♀ presented to the British Museum; taken on various dates.

The species is very close to *C. andersoni*, Edw., differing in the less extensive golden-scaled area of the mesonotum and in the light undersides of the femora. The hypopygium shows only small differences from that of *C. andersoni*; the structure appeared constant in nine specimens mounted, but a single male was also

examined which, while exhibiting the colouration of *C. vansomereni*, had a hypopygium (fig. 11, *d*) exactly like typical *C. andersoni*.

### **Culex trifilatus**, Edw.

This species, though with quite a different hypopygium, resembles *C. vansomereni* in colouration even more closely than does *C. andersoni*. The only distinctions I have noted are that the pale mesonotal scales are more extensive but do not tend to form a pair of patches in the middle; the dark-scaled portions of the femora are more extensive, the hind femora having nearly the outer half dark all round; and the pale spot at the tip of the hind tibia is rather smaller.

### **Culex pallidocephalus** (Theo.) Edw. (fig. 11, *e, f*).

Though very similar to *C. vansomereni* and *C. trifilatus*, this species may be distinguished rather easily by a number of small details of colouring. The proboscis of the female is more or less distinctly pale on the underside about the middle. Mesonotal scales nearly all dark; hardly any golden ones even round the front margin. Abdominal sternites without black apical bands, the dark scales fewer in number and tending to form an interrupted longitudinal stripe. Undersides of femora more extensively white; on the hind femora this colour reaches to about four-fifths of the length. Pale spot at tip of hind tibia smaller, being shorter than the breadth of the tibia. The hypopygium of this species is figured for comparison with those of *C. vansomereni* and *C. andersoni*.

### **Culex mirificus**, Edw.

I am still unable to point out any distinction in colouring between this species and *C. pallidocephalus*, but *C. mirificus* seems to have rather shorter and less hairy male palpi, resembling those of *C. fatigans* rather than those of *C. pipiens*.

### **Culex pipiens**, L.

The females of this species from East Africa as well as the Mediterranean region show a strong tendency to reduction of the abdominal bands, and many of the unbanded examples are not easy to distinguish from *C. laurenti*, the only obvious difference being the rather longer upper fork-cell. From all the other species of the group East African examples of *C. pipiens* differ in having hardly any trace of a pale spot on the outer side of the hind tibiae at the tip; this, however, is not a specific character as the spot is distinctly present in North European specimens. The integument and scales of the mesonotum are lighter than in the four species just mentioned; mesepimeron almost all pale; abdominal bands with more distinct yellowish tinge, and in the female (when present) rather more rounded; hind femora white almost to the tip on the lower and outer side. The male palpi are longer than the proboscis by more than the length of the last segment; the last two segments and the end of the long segment are rather densely clothed with long hairs.

### **Culex fatigans**, W.

Males of this species can nearly always be distinguished from those of *C. pipiens* by the palpi, which are longer than the proboscis by scarcely the length of the last segment, and are distinctly less hairy, the long segment having only a very few hairs at its tip, which tend to project downwards instead of outwards as in *C. pipiens*. Further, the abdominal bands are whiter (though not pure white like those of *C. univittatus* and *C. simpsoni*) and in the female are very distinctly rounded. The hind tibia nearly always has a distinct though not very large pale spot at the tip. As in *C. pallidocephalus* and *C. pipiens* the proboscis is paler beneath in the middle.





← TWO NEW SPECIES OF AMERICAN *LEPTOCONOPS* (DIPTERA,  
CHIRONOMIDAE).

W. A. HOFFMAN, Sc.D.\*

Examination of a limited number of specimens of *Leptoconops* occurring in America indicates that at least several undescribed species exist in North and Central America and the West Indies. Paucity of material, however, prevents any detailed study of the group for the regions mentioned. Two members of the genus have, through their biting tendencies, made themselves decidedly obnoxious in the sections where they occur. Description of these follows.

**Leptoconops (Leptoconops) carteri**, sp. nov.

♀. Length, 2.7-3.05 mm.; length of wing, 1.0 mm.; width, 0.42 mm.; length of antenna, 0.32 mm.

Head black, slightly shining, the antennal depressions lined with what seems to be a fine yellowish-brown pruinescence; upper portion of frons bluntly carinate, fusing with vertex. Eyes widely separated, the distance between their inner margins at the vertex fully one-third of the head width. Proboscis black. Palpi (fig. 1, r) blackish brown, third segment ovoid, decidedly swollen, the orifice more or less elliptical, occupying about half of the area of the inner surface; fourth segment elongate, approximately as long as the third; the tip of the third and base of the fourth are lightly chitinized, as is the case with the greater portion of the two basal segments; the second much shorter than the first. Antennae (fig. 1, A) black, composed of 14 segments bearing minute hairs, others longer, yet thin, some spinose, brown, a few curved and clear; fourth to thirteenth inclusive transversely globose, three-fifths as long as wide, length of terminal segment slightly more than twice its width. Thorax black, shining, surface covered with a fine pruinescence, with relatively few brown hairs, these tending to be arranged in rows. Scutellum and metanotum similar in coloration to mesonotum, former with six long thin brown hairs. Wing white, with the usual stigmal area (fig. 1, K); the second radial cell is indistinctly indicated; in some specimens the second fork of vein M almost reaches the stem just before the middle of the wing, in others the atrophy of this branch is more noticeable; the apical portions of the median and cubital veins fail to reach the edge; Cu forks directly below the tip of the stigmal area. Pedicel of haltere dark brown, apical portion yellowish brown. Surface of pectus similar to that of mesonotum. Legs uniformly dark brown, clothed with dark hairs, none of which are of a spinose nature except possibly those at the apices of the metatarsi and a few on the ventral surface of the hind metatarsus. Claws equal and simple. Abdomen brownish black, shiny, sparsely clothed with brown hairs, second to fifth segments inclusive with four pairs of sensory areas or "windows." Lamellae (fig. 1, o) of a slightly lighter shade than the abdomen, the tips rounded more obtusely than in other species noted. There are two pairs of ovipositors, each shaped like a Culicid maxilla, more strongly developed than in other forms observed, length a trifle less than one-fifth of that of the wing. Spermathecae two (fig. 1, M), heavily chitinized, ovoid, about  $0.044 \times 0.03$  mm. in size; the origin of the duct only chitinized, a spirally arranged chitinized ridge encircling the proximal portion of the duct.

An extensive series from Maine Prairie, 15.vi.1922 (B. G. Thompson); Franklin, 27.v.1921 (C. M. Packard); Bird's Landing, 10.vi.1925 (C. M. Packard). These localities are in the Sacramento Valley, California. A number of cotypes have been

\* From the Department of Medical Zoology of the School of Hygiene and Public Health, Johns Hopkins University, Baltimore, Md.

chosen from this material, one being deposited in the British Museum, the collection of the School of Hygiene and Public Health, Johns Hopkins University, and that of the writer, the remainder in the United States National Museum. This form is named in honour of Mr. H. F. Carter, whose excellent revision of the genus has greatly facilitated the preparation of this paper.

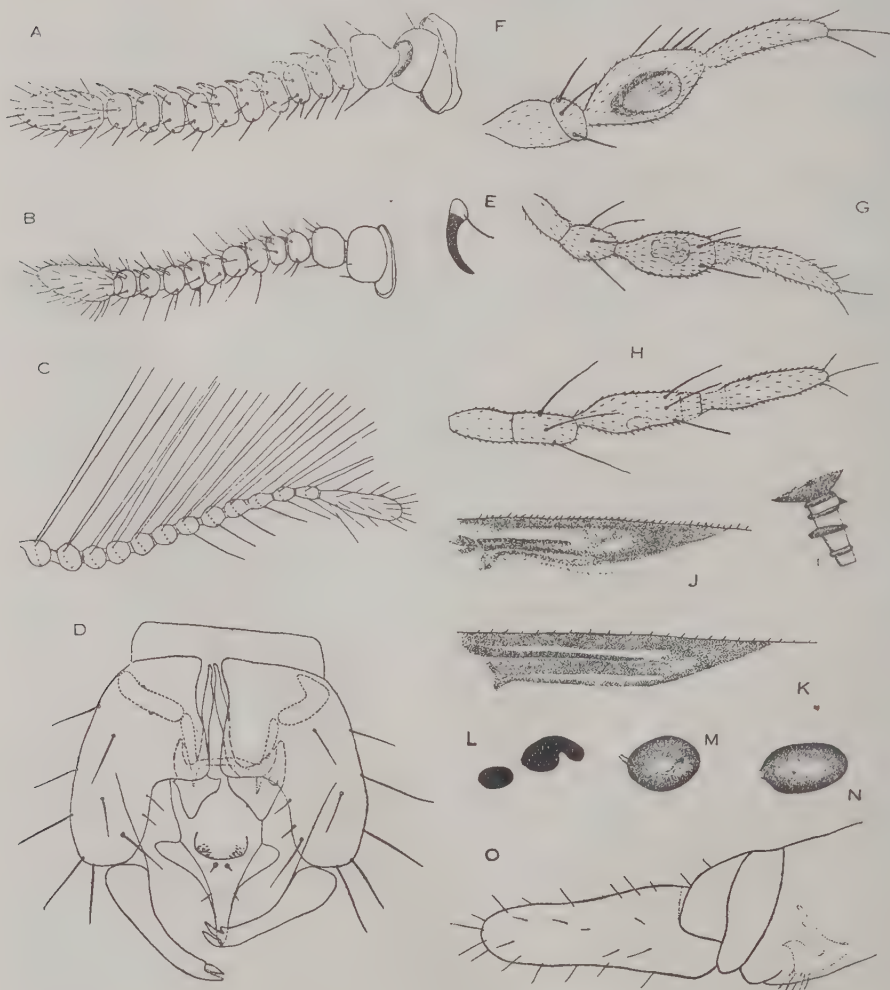


Fig. 1. A, antenna of *Leptoconops carteri*, ♀; B, antenna of *L. hondurensis*, ♀; C, antennal flagellum of *L. hondurensis*, ♂; D, genitalia of *L. hondurensis*, ♂; E, claw of *L. hondurensis*, ♂; F, maxillary palpus of *L. carteri*, ♀; G, maxillary palpus of *L. hondurensis*, ♀; H, maxillary palpus of *L. hondurensis*, ♂; I, basal portion of duct leading from spermatheca of *L. carteri*, ♀; J, basal portion of wing of *L. hondurensis*, ♀; K, basal portion of wing of *L. carteri*, ♀; L, thoracic sensory organ of *L. hondurensis*, ♀; M, spermatheca of *L. carteri*, ♀; N, spermatheca of *L. hondurensis*, ♀; O, lamella of *L. carteri*, ♀.

This species apparently occasions considerable annoyance, as the following excerpts of a letter from Mr. C. M. Packard, of the United States Bureau of Entomology, indicate: "The adults occur only in late spring and early summer, so far as our personal experience and discussions with residents of the infested districts indicate . . . The gnats have a special tendency to crawl under the edges of one's cuff, collar and hatband, and bite at those points, though any exposed skin is subject to attack. Outdoor people often protect as much as possible of their heads and necks by inserting the upper edge of a piece of cloth under the hat and lower edge under the collar. They are very annoying while working in the fields because they swarm about the person in clouds, crawl among the hairs of the skin and bite vigorously. Their bites itch and swell somewhat like a mosquito or bedbug bite, and when very abundant make work in the fields almost unendurable. Often the faces and hands of persons who have been bitten many times become very much swollen."

***Leptoconops (Holoconops) hondurensis*, sp. nov.**

♀. Length (front margin of thorax—tip of lamella, carbolic specimen), 1.3–1.5 mm.; length of wing, 0.86 mm.; width of wing, 0.44 mm.; length of antenna, 0.23 mm.

Head dull brownish black, antennal depressions dark grey; frons and clypeus prominent, latter somewhat darker; eyes widely separated, the distance between their inner margins at the vertex slightly more than one-third the head width. Proboscis dark brown. Palpi (fig. 1, c) blackish brown, third segment elongate-ovoid not excessively swollen, the orifice of the sensory pit occupying about one-fourth of the inner surface; the lightly chitinized portion at the apex of the third and base of the fourth segments quite extensive; second segment approximately as long as first. Antennae (fig. 1, b) with 13 segments, dark brown, covered with hairs of varying lengths and with slightly curved transparent spines; segments 4 to 12 inclusive slightly transversely globose, 1.14–1.5 as wide as long, length of terminal segment four times its width. Thorax blackish brown, shining, covered with greyish pruinescence, sparsely clothed with dark hairs. The sensory organs in the humeral region are relatively conspicuous (fig. 1, l), consisting of two more or less ovate plates, the inner considerably larger and with a posterior indentation. Surface of scutellum and postnotum similar to that of mesonotum, former with a central pair of stout dark bristles and a shorter lateral pair. Wing white, basal portion as in fig. 1, j; the stigmal portion barely fails to attain the middle of the wing; the fork of vein Cu almost below that of M, both being basad of the termination of the stigmal area. Pedicel of haltere brown, apical portion yellow. Legs yellowish brown, clothed with dark hairs, some long, especially on the femora; with small spines at the apices of the two hind pairs of tibiae and of most of their tarsal segments; claws simple and equal. Abdomen yellowish brown, the caudal portion darker, apical margins and venter yellow, clothed somewhat sparsely with brown hairs. Lamellae yellowish, 0.19 the wing length. Spermathecae two (fig. 1, n), heavily chitinized, elongate-ovoid, the ducts non-chitinized.

♂. Length (fore-margin of thorax—tip of abdomen, carbolic specimen), 1.14 mm.; length of wing, 0.87 mm.; width of wing, 0.31 mm.; length of antenna, 0.4 mm.

The male differs in that the antennae (fig. 1, c) are composed of 15 segments, the segments of the scape tend to be longer than wide, the terminal segment slightly less than four times as long as wide; on segments 9 to 14 there is a long hair, the base of which is set just distad of the ring from which come the hairs making up the golden plume. The eyes are slightly further apart. The basal portion of the wing along and below the costa is much less noticeable. The genitalia (fig. 1, p) differ from the usual *Ceratopogonine* type in that the portion of the ninth tergite situated between the side-pieces is trilobed and apices of the claspers are tridentate.



Six cotypes, three males, Puerto Castilla, Honduras, 27.v.1926, one female, Puerto Castilla, 24.v.1926 (*R. H. Painter*); and two females, Tela, Honduras, 16.vi.1924 (*Dr. F. M. Root*). Five have been deposited in the United States National Museum, one in the collection of the school of Hygiene and Public Health, Johns Hopkins University. I have also received material collected at Puerto Castilla by *Dr. Bequaert* in 1924 and by *W. H. W. Komp* in the same locality April 1926. A specimen from Barcoa, Cuba (*August Busck*) agrees with this species and possesses the identical thoracic sensory organ pattern. If this character be relatively constant for a species, it will prove to be of considerable value in differentiating dry mounted specimens. The more or less uniform appearance of the species of this genus (at least those thus far observed) makes identification extremely difficult.

*Leptoconops hondurensis* has been a source of annoyance at stations of the United Fruit Company along the east coast of Honduras for some time, especially at Puerto Castilla.

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## THE BANANA FRUIT-SCARRING BEETLE (*COLASPIS* *HYPERCHLORA*, LEF.).

By C. C. GOWDEY, B.Sc., F.E.S.

During recent years banana plantations in some parts of tropical America have suffered somewhat severely from attacks of a Eumolpid beetle, *Colaspis hyperchlora*, Lefevre (1878). This species has up to now been recorded from the following countries: Colombia (type locality), British Guiana, Panama, Costa Rica, Guatemala, Nicaragua, British Honduras and Mexico.

The egg is pale lemon-yellow in colour, becoming brownish as the embryo approaches maturity, and broadly oval in shape with one end slightly more acute than the other; length, 1.2 mm. The larva is whitish, with the head somewhat amber-coloured, the body being slender and hairy; length, 1-1.5 mm. The pupa is dirty yellow, becoming darker as the adult becomes ready to emerge.

The eggs are deposited singly or in clusters varying in number from 5 to 45, in cavities gnawed by the female in the leaf-sheath of bananas near the crown just above the surface of the ground, on the surface roots in natural depressions or in cavities made by the female, and on the surface roots of the old "mats." The duration of the egg stage is from 7 to 9 days.

The larvae feed on the young roots, gnawing the soft epidermal tissues of the older roots, into which they tunnel. The duration of the larval stage is from 20 to 22 days.

The pupae are found in the soil at a depth of from 2 to 3 inches and within a radius of 3 ft. from the "mat." Transformation from the larva to the pupa often takes place in the cavities around the dead roots. The duration of the pupal stage is from 7 to 10 days.

There are apparently four broods. The first appears usually during the first part of April, the second towards the end of June, the third towards the end of August, and the fourth at the end of October or at the beginning of November.

The optimum conditions for the development of this insect are poor drainage, heavy shade, poor cultivation and heavy soil. It is disseminated by: (1) the transportation of the immature stages on suckers taken from infested areas; (2) the transportation of the adults on bunches of fruit; and (3) by flight. The first of these is probably the chief means of dispersal, although the adults are capable of flying considerable distances. The second factor is not so important as it may appear, for most of the adults take flight before the bunch of fruit reaches the ground, though occasionally an adult feeding at the base of a "finger" is transported long distances, despite the frequent handling the fruit has received.

This insect attacks the fruit, the leaf and the roots of the banana, the injury to the fruit being the most serious. The beetles begin attacking the bunch when it is about 10 to 14 days old, and at first the point selected is at the junction of the "hand" and fruit stem; then they attack the "fingers," feeding upon the epidermal tissues of the fruit and causing unsightly scars; and though the injury does not extend into the edible portion, it renders the fruit unsaleable.

The attack by the adults on the leaf is restricted to the young uncurled leaves, but is not serious enough to affect the growth of the plant. The attack on the roots by the larvae apparently causes no perceptible injury.

The recorded food-plants of the beetle are: Banana, rose bushes (G. E. Bodkin), *Lantana camara* and *Antigonon leptopus* (F. W. Walker), and *Coccoloba* sp.



## NOTES ON THE FROGHOPPER BLIGHT OF SUGAR-CANE IN TRINIDAD.

By E. PHILPOTT MUMFORD.

### General Introduction.

Having been asked to gather together a few notes concerning the "froghopper blight" of sugar-cane in Trinidad to lay before a special meeting of Trinidad Proprietors and Scientific Experts held recently at the West India Committee Rooms, the writer became so interested in the problem that he desired to make still further inquiries. He had already interested himself in a study of the factors which tended to increase the susceptibility of plants to the attacks of certain insect and fungus pests. The results had been embodied in the form of a paper in which the effects of unfavourable climatic and soil conditions in lowering the natural resistance of plants to pest attack was discussed.<sup>(26)</sup> It seemed advisable, however, to see how far the conclusions already arrived at in these general studies applied also to the froghopper blight of the sugar-cane. The present paper, therefore, is an extension of a line of thought which seemed to offer promising results. It can in no sense claim to be based upon personal observations, and it can only be tested by practical experiments on the spot. Nevertheless, it seemed worth while to make a preliminary survey of what had already been done by so many skilled workers in Trinidad, and particularly by Mr. C. B. Williams, Mr. Nowell and Mr. Ulrich.\* Moreover, the importance of the water-balance as a predominating factor in the resistance of plants to the attacks of sap-feeding insect pests has not been dealt with in earlier papers, so far as the writer is aware.†

Thanks are due to Sir Arthur Shipley, Chairman of the Governing Body of the Imperial College of Tropical Agriculture in Trinidad; to Dr. Martin Leake, Principal of the College; to Dr. C. A. Barber, Lecturer on Tropical Agriculture in the University of Cambridge; and to Dr. Willis, Editor of the "Empire Cotton Growing Review" and sometime Editor of the "Tropical Agriculturist." Thanks are also due to Professor Balfour Browne, Mr. Brooks and others, who have been kind enough to give their advice from time to time, and who have read through this paper before publication. The writer is also indebted to Mr. J. Gordon Miller, Chairman of the Board of Directors of the Caroni Sugar Estates, Ltd., and to Mr. Aspinall, Secretary to the West India Committee, for their kind help and interest.

In the Tropics—as already stated in a summary of this paper published in the February number of the West India Committee Circular<sup>(28)</sup>—there is a ceaseless warfare between the crops grown by man and the insects which attack them. To a certain extent it is within our power to influence the ultimate results of the attack, partly by attempting to eliminate the pest, and partly by increasing the resistance of the plant to such an extent as to render negligible the damage caused. Both methods help and both are essential. In the past, the economic entomologist has directed his attention almost wholly to the first method; it is now realised that the second method is of equal—in some quarters it is thought of even greater—importance. A few years ago, writing in the "Bulletin of the Department of Agriculture" in Trinidad, C. B. Williams told us that "after ten years' work" we were still "without any direct means of destroying the froghopper." Professor Ballou, Mr. Ulrich,

\* Since this paper was written, Dr. Withycombe has published an account of some of his experiments in connection with this pest in Trinidad (*Ann. App. Biol.*, xiii, pp. 64–108.).

† The subject has been discussed in some detail in a special report on "Cotten Stainers and certain other Sap Feeding Insect Pests of Cotton," published by the Empire Cotton Growing Corporation, 1926 (*Bibliography*, no. 26).



Dr. Withycombe and others are, however, still devoting special attention to the problem. Meanwhile, we need to consider a further problem, *viz.*, how far we can encourage the plant to resist attacks, and how far it is possible to obtain a variety which is partially immune from "blight." Before we can do this, we need a fuller understanding of the predisposing causes (diathesis). For over 60 years a vast mass of evidence on the frog hopper has been accumulating.

### **Economic Importance and Main Causes of the Frog hopper Blight.**

The frog hopper blight of sugar-cane has been defined as a disease or complex of diseases, consisting of a "browning and drying up of the leaves of the cane and a decay of the root system, which results in more or less complete cessation of growth, an appearance throughout the field "as if scorched by fire," and a loss ranging from a slight check in growth to complete destruction of the crop. "Uncomplicated frog hopper attack" is said to be "distinguished from uncomplicated root disease by the presence of brown streaks on the leaves." "From each puncture of the adult frog hopper on the leaf, an elongated area of injury spreads, at first pale and later brown. Increase in size of this spot may continue for as long as four or five weeks and, from an almost imperceptible point, the damaged area may reach five inches in length and a quarter of an inch in width, forming a long discoloured streak on the leaf. The centre of the area finally dies completely. If these streaks are numerous, they may join up to form large dead areas on the leaf."

Losses due to this cause in Trinidad in 1917-18 reached nearly £300,000. These losses are still increasing. Thus, in 1925, the attack was general and the worst ever experienced. All the sugar estates from the Caroni River down to Claxton's Bay were seriously damaged. In September, the total loss of sugar was estimated as being between 25 per cent. and 33½ per cent. of the Island's crop. Since then, however, the partly damaged canes have recovered, but the juice from these will be poor, and the total loss of sugar for the 1926 crop is unlikely to be far short of 20 per cent. Some idea of the rapidity with which damage is done is gained from a realisation of the fact that "fifty frog hoppers per stool, each sucking for eight hours during the night, remove about one and a-quarter pints of sap. This drain would last from two to four weeks in bad attacks."

There are probably two main causes of this disease, namely, the attacks of root fungi (*Marasmius* and *Odonia*) and the attacks of the larvae, nymphs and adults of the frog hopper (*Tomaspis saccharina*). "Blight"—using the term in its wider sense—is not entirely due to insect attack. It may be severe when only a few frog hoppers are present; on the other hand, it may be slight when these insects are present in great abundance. "Fields were badly damaged," writes C. B. Williams, "when only about ten adult frog hoppers per stool could be seen at the height of the brood; other fields, in which thirty or forty adults per stool could be seen, were only slightly injured. One field, in which 20,000 adult frog hoppers were captured in one night in four light traps, suffered but slightly, while a field in which the numbers never rose above 3,000 was almost completely destroyed."

With regard to the attacks of the root fungi, it has been shown that both the onset and persistence of the disease depend upon a condition of weakness or debility of the cane, resulting from unfavourable soil conditions. The general effect produced by the disease is that of shortage of water. A cane with its roots damaged by such an attack ceases to grow and even in moist weather shows symptoms of water-shortage. The injury appears to be most severe in times of drought, particularly when this occurs at an unusual time of the year. Thus it is more conspicuous during dry spells in the wet season than in the dry season itself. Conditions that adversely affect the vitality of the cane tend to reduce its resistance to this disease, so that damage is invariably severe in heavy, badly aerated soils, and in acid or water-logged soils.

The debility of the cane and its consequent susceptibility to the attacks of root disease appear to be largely due to causes which disturb the plant's water-balance, either by deficient root absorption or excessive transpiration. A careful survey of the available evidence suggests that the susceptibility of the cane to froghopper attack may also be due to similar causes. For this reason a full consideration of the factors which affect the cane's water-balance appear to be of fundamental interest.

**Factors affecting the Water-balance of the Cane. The possible Relation of these to the Varying Degrees of Susceptibility to Blight.**

The balance in the water-content of sugar-cane is dependent upon the simultaneous working of the absorption that takes place through the roots and the transpiration that takes place through the leaves; the rate of transpiration depends on the humidity of the atmosphere, temperature, circulation of the air, available water supply, etc. In Java it was found that a single stalk of sugar-cane transpired through its leaves 250 cc. a day\* (equal to about 1,600 tons an acre); during the first month of drought, the transpiration per stalk was estimated at 500 cc. a day (3,200 tons an acre). Maxwell found that when cane was grown in tubs, in seven months 79,310 grms., or 174.5 lb., of water were transpired by each plant. When transpiration is excessive, too great a demand is made on the available water supply in the soil. Trinidad possesses one marked advantage over the other West Indian islands in the humidity of its climate. Barbados is very much drier, both in soil and climate, and the tendency to root disease in that island is largely increased by this shortage of moisture.

Favourability in climate can, however, be offset by unfavourable soil conditions. The problem of the maintenance of the plants' water-balance is an extremely complex one. The distribution of the rainfall, soil conditions (as regards water-logging, defective soil-aeration, acidity, etc.), the degree of humidity, the effect of the disturbance of the water-balance upon the concentration and constitution of the cell sap, etc., all need to be taken into account.

With regard to the distribution of the rainfall, both conditions of drought and excessive rainfall have been shown to be particularly harmful, causing the sugar-cane to decline in health and therefore favouring the prevalence of blight. (2, 3, 21, 31, 41, 42.)

Excessively heavy rains may be followed by water-logging and defective soil-aeration. Under these conditions the delicate root hairs of the cane are unable to perform their proper function of absorbing water from the soil; the cane is therefore said to suffer from "physiological drought."

According to C. B. Williams, unusual alternations of wet and dry periods tend to produce a similar effect. There is strong evidence, he asserts in a paper on "Rainfall, Sugar Production and Frog-hopper Blight in Trinidad," that under these circumstances blight is more widespread. What is the explanation of such a connection? Attention has been drawn by certain botanists to the harmful effects of bright sunshine following spells of cloudy, moist weather, under which conditions the plant suffers from desiccation, the excessive loss of water being attributed to the fact that the leaves produced in very moist air were not adapted to resist excessive transpiration.

In this connection, Dr. Z. Kammerling's statement with regard to the sugar-cane (Congresverslag, 1900), *viz.*, that the power of the cane to regulate transpiration is

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\* Presumably under normal conditions of humidity. The statement is based on some of Kammerling's experiments in Java. Unfortunately, I have not yet been able to obtain a copy of the original paper in which his experiments were published (Proc. Fourth Congress, United Synd. Java Sugar Manufacturers, 1904).

very limited and that a regular supply of water is therefore necessary for healthy growth, is suggestive. Is this, however, a sufficient explanation of C. B. Williams' conclusions? Would the mere alternation of wet and dry periods—it has been asked—have any serious effect on the vigour and vitality of the sugar-cane if the dry period did not become a prolonged drought, and the wet periods did not cause the soil to become water-logged for a considerable time?

### **Root Absorption considered in connection with Soil Conditions.**

In view, therefore, of the peculiar importance of root-absorption, the soil factor is worth considering in some detail. Blight is invariably more severe on canes growing in soils which are in a poor physical condition; improvement of drainage and soil-aeration is generally followed by a decrease in blight. When the soil is uniform over large areas, the blight is found to be uniformly spread over whole fields or even larger areas. When the soil is more irregular, blight is more patchy.

The physical condition of the soil mainly has effect through its influence on free and deep rooting. Various factors—poor drainage, defective soil-aeration, soil-acidity, etc.—have been shown to affect the health of the cane in such a way as to render it increasingly susceptible to the attacks of root-disease and froghopper; and both poor drainage and defective soil-aeration tend to prevent the development of a deep and a copious root system. When the sugar-cane is supplied with sufficient quantities of water, the stomata are more widely opened and consequently more intensive assimilation and more vigorous growth becomes possible. It is therefore necessary that the soil should be in good condition, and that the sugar-cane should have a strong, extensive and deep root system. If this is fully developed, a little less water evaporates than is supplied (the surplus is used for growth), and assimilation can go on without interruption. "In the contrary case, more water evaporates than is supplied . . . the stomata close, the leaves curl up and assimilation diminishes or ceases."\* The thirsty plant starves.

Both the soil temperature and the chemical composition of the soil are also of importance. Nothing is known so far as to the exact effect of soil temperature on the root disease of sugar-cane. With regard to the chemical composition of the soil, various attempts have been made to correlate this with the extent of froghopper blight. Undamaged fields were found by C. B. Williams to be alkaline or neutral in reaction, with a higher content of lime, carbon dioxide and humus. Damaged fields were found to be neutral or acid with a lower percentage of lime, carbon dioxide and humus, and possibly a higher relative amount of  $\text{SO}_3$  (<sup>42</sup> p. 158). How far are we able, by various agricultural methods, to improve the condition of the soil and thus increase the resistance of the cane to blight? Such remedial measures might consist in improved methods of cultivation, rotation of crops, manuring, etc. In many of the blighted areas, or areas subject to blight, it has been found that there is a conspicuous deficiency in tilth, probably due to an insufficiency of organic matter in the soil, and any process which tends to bring the soil to a more open, lighter and looser state should have some effect in removing the blight. The beneficial effects of cultivation are well illustrated by the following examples(<sup>42</sup>): "Two fields of young plants, side by side, on Tarouba Estate in 1918, were both the same age, but differed only in that the manager had been able to give one of them a more complete cultivation than the other. In the less cultivated field, not only was the soil in a visibly poorer tilth and the young canes much weaker, but froghoppers were at least ten times more abundant." "A still more striking case was at Harmony Hall, when, in September 1918, half of the field badly damaged by froghoppers was forked throughout between the rows and down the edges of the drains. No particular effect

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\* The Cultivation of the Sugar Cane in Java (1923).



was noted that year, but the following July the first brood of froghoppers was at least twice as abundant on the unforked part of the field as on the forked part, and leaf damage was much more obvious. There was, in fact, a distinct line across the field separating the badly damaged area from the slightly damaged area, and this line corresponded to the division of the forked area from the unforked."

With regard to the effect of rotation of crops on the influence of "blight," in his Report on the Froghopper Blight in Trinidad (1921), C. B. Williams writes, "In the greater part of the sugar area of Trinidad, either no rotation at all is in practice . . . or a very primitive and inefficient rotation is made by abandoning the land for a longer or shorter series of years between successive cane plantings . . . Neither of these systems has anything to recommend it from the point of view of the control of the blight . . . Many examples could be given of severe blight in fields which had been abandoned for years." In 1919, Nowell had already written: "What is most required for Trinidad agriculture is a rotation crop with a value sufficient to secure, without a sense of sacrifice, its alternation with cane, as a general practice."

With regard to the application of manures it is asserted that "pen manure" could be used with advantage, but in the Tropics the difficulty lies in obtaining a sufficient quantity. In view of the importance of acidity in connection with blight, it has been suggested that continued applications of artificial manures should be counteracted by applications of lime.

In connection with the effect upon the plant's resistance of the distance and depth of planting and the variety and period of ratooning of the cane, the evidence points in the direction of the advisability of further experiments. In general, the most economical width of row is said to be determined by the fertility of the soil. In very fertile soil, the rows are placed comparatively far apart to allow freedom of growth to the luxuriant crop, and conversely, as the soil becomes less productive, a narrow row gives more economical results. Under conditions of labour shortage, however, it would seem that the grower has to choose between the facilities for rapid inter-row cultivation with wide cultivation and reduction of weeding by close planting.

With regard to the depth of planting, there appears to be some difference of opinion. C. B. Williams (1921) states that "there is no evidence that the depth of planting affects either the depth of the root system or the amount of blight." H. W. B. Moore (1919), on the other hand, recommends planting as deeply as possible. Is the apparent difference of opinion due to a difference in the nature of the soil? Moore reports from Georgetown, Demerara; C. B. Williams from Trinidad. According to C. W. Hines (1917), it is a good practice to locate the root system at a sufficient depth, especially in loose soils that are likely to dry out, in order to have them within reach of a sufficient supply of moisture at all times.

### **The Root System of the Cane.**

The development of a strong root-system appears to depend upon the existence of a sufficient supply of moisture and oxygen. When the sub-soil is in a bad condition, a superficial root system is produced with all its attendant evils. How far is the depth of the root system likely to influence the vitality of the plant in such a way as to affect the cane's resistance to root-disease and frog-hopper attack? Under certain soil conditions a potentially deep-rooted variety would be unable to form its deep root system, and would therefore still suffer in times of severe drought, the consequent loss of vitality being followed by an increased susceptibility to pest attack. Resistance to attack depends on vigour and health, which are again dependent on the successful adaptation of the cane to its environment. If environmental conditions are sufficiently unfavourable the most resistant variety will tend to become susceptible. In very severe attacks of blight (*e.g.*, in 1912, 1917, 1925)



no variety is found to be immune or resistant, but, on the whole, a deep-rooted cane appears to be generally less susceptible to drought and therefore to blight.

The Uba and Badila canes are stated to be the two most resistant varieties. The former is said to be deep-rooted; the latter is definitely known to have a good root system, the bulk of the roots going down to nine inches and many roots penetrating two feet. The old Bourbon cane, which was susceptible to drought, fungoid diseases and insect pests, was very shallow-rooted. The difficulty is that both the Uba and Badila varieties produce a cane which is short, very hard and heavy, and therefore difficult to mill.

The distribution of the rainfall and the condition of the soil not only affect the water-content of the sugar-cane directly through their effect upon the percentage of available water in the soil, but also indirectly through the type of root-system produced.

The roots of the cane are fibrous, adventitious and very delicate; they spring from the nodes of the stem, ramifying in all directions and penetrating into the ground to a lesser or greater extent. As to the depth to which the roots extend, H. Ling Roth—reading a paper “On the Roots of the Sugar Cane” before the Royal Society of New South Wales on 3rd October 1883—mentioned roots extending as far downwards as four feet nine inches. He goes on to say that “it is much to be regretted that so few writers on the sugar-cane have given any attention to the roots.” “In a new work\* on sugar-cane,” he continues, “a totally erroneous impression concerning the roots of the cane is conveyed to the mind of the reader. . . . A drawing of a cane is given with its so-called root, but the cane, as drawn, only goes so far as to give the point of its attachment to the parent plant cane, and does not show either the root stems (*i.e.*, rhizomes) or the roots.” At this same meeting, Professor Liversedge stated that he had seen at Maryborough, in Queensland, roots of the sugar-cane extending down from 8 to 10 feet, where they had been exposed by the cutting away of a bank, and he had been informed by planters that they had traced roots down to a depth of 12 to 15 feet in light alluvial soil.

A shallow-rooted cane, such as the Bourbon cane, is susceptible to drought, responds very quickly to untoward soil conditions, and possesses a very low degree of immunity from various fungus diseases. It would be equally susceptible to the attacks of froghoppers and root fungi. The breakdown of the Bourbon cane (which was the standard cane in the British West Indies from 1800 to 1900) has been said to be due to the introduction of the fungus, *Colletotrichum falcatum*, causing the “red rot” of the stem. Attacks of “red rot” disease in India are said to be one of the consequences of poor soil-aeration, following the destruction of the tilth. Control methods, therefore, consist in the preservation of the tilth rather than in the attempted destruction of the fungus. Possibly the breakdown of the old Bourbon cane may have been due to similar causes, resulting in an increased susceptibility to “red rot,” as well as to the attacks of various insect pests. Howard has described a certain variety of cane (Hemja) grown in Bihar, which develops both deep and shallow root systems according to the climatic and soil conditions. Planted in February, it develops a root system so deep that, during the hot months of April and May, when deep-rooted crops like Java indigo often maintain themselves with difficulty, it is able to grow without irrigation. During the rains, when the aeration of the subsoil falls off, it develops a more superficial root-system.

A botanical survey of the root-systems of West Indian sugar-canecan in relation to the soil and climatic conditions might throw further light upon the subject.

The problem is an extremely complicated one. How far is a deep-rooted variety of cane generally more resistant, not only to froghopper blight, but to various other

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\* “Sugar-growing and Refining,” by Lock, Wigner & Harland.

insect and fungus pests? What is the maximum length of root system characteristic of the more resistant canes when grown in optimum environmental conditions? Are there any sugar-cane estates in which blight has never been known to occur? If so, are these favoured areas due to absence of infection as the result of isolation, or are the soil conditions of such areas particularly favourable to the absence of blight? What light does an examination of the root system of canes grown in these areas throw upon the problem of the plants' susceptibility? It has been said that blight occurs even under the best soil conditions possible. In such cases, what is the predisposing cause of this blight, and had this cane a deep or a shallow root system?

### **A possible Physiological Basis to the varying Susceptibility of Canes to Froghopper Blight.**

The physiology of the cane has been studied by Went and Kamerling in Java. The first product of metabolism in the leaf appears to be saccharose or sucrose ( $C_{12}H_{22}O_{11}$ ), but if more carbohydrate is formed than can be transported by the stem, the excess appears as starch, which, during the daytime, is stored in the chlorophyll granules. During the night, or even on a cloudy day, this starch is converted into reducing sugars, and in this form is transported to the stem. The presence of large quantities of starch can be demonstrated in leaves cut just before sundown, and, conversely, its almost complete absence can be shown in leaves cut before sunrise. It is important to notice that the water-content of the cane varies under certain conditions of soil, climate, etc., and this may result in some change in the cell sap, *e.g.*, an altered percentage of reducing sugars.

These reducing sugars (monosaccharides,  $C_6H_{12}O_6$ ) consist almost wholly of glucose and fructose, which are present as intermediate products in the formation of sucrose in normal canes, and as degradation products in damaged and over-ripe canes. Owing to the facility with which the various forms of sugar pass into each other, the character of the cane sap varies—sometimes containing more of one form, sometimes more of another form of sugar; it is important to recognise the rhythmical nature of this process of metabolism, since it is at night, when these reducing sugars are most abundant, that the froghopper feeds. "In the late afternoon and early evening," writes C. B. Williams, "the adults gradually leave their hiding places and come out on to the leaves. This takes place earlier or later, according to the condition of the day. On wet, cloudy, overcast days, they begin to come up about 4.30 in the afternoon and have been seen in thousands sitting on the leaves by 5 p.m. On hot, clear days they seldom start to move until 5.30 and are usually mostly out shortly after 6." "In Trinidad the sun sets about 6.45 in July, and about 6.15 in October and November. In the early morning the reverse process takes place to that in the evening, and by 7.30 a.m., according to the brightness of the day, all the adults have returned to their hiding places in the axils of the leaves." On some form of sugar the froghopper is said to feed.

Disturbances in the metabolism of the cane are said to result in an increase of reducing sugars as degradation products. These reducing sugars are much sought after by insects. Possibly this is why diseased and damaged canes have always been said to be more attractive to the froghopper. During conditions of extreme drought—physiological or actual—this metabolism of the cane is seriously disturbed, for the stomata close, assimilation diminishes or ceases, and starvation follows. Under such conditions the cane is particularly susceptible to the attacks of pests.

According to Comes, "an increase in the quantity of reducing sugars is attended by a reduction of organic acids, and vice-versa"; so that, in his opinion, acidity is "the weapon most used by the plant against animal parasites." It is difficult to see, however, how far the resistance of certain canes to froghopper blight can be

due to the presence of organic acids in the sugar, for C. B. Williams (1921) tells us that the juice of blighted canes is considerably more acid than normal juice. Is this acidity of the juice due to the sucking of the froghopper or is the froghopper more attracted to canes which have already a juice made acid from other causes? This important question was first raised by Carmody nearly seventeen years ago.

Is it possible that the excessive acid of the cell sap in diseased canes might exert some influence on the formation of hydrolysis products? We are told by C. B. Williams that he was "informed that the sucrose in blighted canes inverts more easily than in normal canes." Moreover, it is a well-known fact that cane sugar in acid solution is converted into equal parts of glucose and fructose. The process, though commonly called inversion, is actually an hydrolysis; the rate of inversion would be dependent on the concentration of the hydrogen ions. Dr. Gough (1911), however, pointed out that blighted canes, when they came to the factory, contained a higher percentage of sucrose. Further analyses would appear to be called for.

A still further question suggests itself. Is it possible that the formation of such hydrolytic products might be due to the secretion of enzymes by the attacking fungi? The outstanding feature, for example, of the attacks of *Colletotrichum falcatum* on sugar-cane has been shown to be the inversion of the sucrose. Various kinds of hydrolytic enzymes are known to occur amongst other fungi, amylase or diastase, cytase, lactase, maltase, raffinase and trehalase are all examples of carbohydrate-splitting enzymes. Invertase, which hydrolyses sucrose to glucose and fructose, has been traced in *Sacchromyces*, *Fusarium* and *Aspergillus niger*; Lewton Brain<sup>(19)</sup> showed that the fungus causing red rot of the stem (*Colletotrichum falcatum*) also secreted an invertase causing the inversion of sucrose. He found that the main action of the fungus was the conversion of sucrose into invert sugar; that the invert sugar destroyed was very small in amount, and appeared to be all levulose (fructose); and that the inverting power of the fungus was due to the secretion of a definite enzyme, invertase, which was shown to be contained in the mycelium, and also to be secreted into the media in which the fungus was growing. The fungus is capable of inverting nearly the whole of the sucrose in a solution. Various enzymes are known to exist in the normal cane. Thus Browne<sup>(4)</sup> found an invertase mainly resident in the tops, and Raciborski<sup>(32)</sup> identified a laccase and peroxidase, to which Zerban<sup>(44)</sup> has added a tyrosinase.

How far are disturbances in the metabolism of diseased canes accompanied by the excessive activity of enzymes already present in normal canes? The problem is still further complicated by Kershaw's theory that the "saliva" of the froghopper is "full of enzymes." The evidence at present available appears insufficient to draw even tentative conclusions. It would be of enormous interest to discover what form of sugar is most attractive to the froghopper.

### How far does a vigorous healthy Cane tend to be resistant to Attack?

"Scattered throughout the writings on blight," writes C. B. Williams, "one finds continued references to the possibility that the canes diseased, or damaged by other causes, are more attractive to the froghopper than are healthy canes; and that when froghoppers are found in numbers in a blighted field it is possible that the infestation is the result and not the cause of the trouble.

Disputes as to how far the vitality and health of the cane influence resistance largely appear to be due to a misconception of the term "health." Health implies the ability to resist the disintegrating forces of adverse environmental conditions; that is, it implies a successful adaptation to the environment. A cane does not need actually to be attacked by root disease to be unhealthy. The predisposing physiological condition, due to the adverse environment or unsuitability of the variety, itself constitutes "ill-health." The presence of an infecting agent, taking



advantage of its susceptibility, merely intensifies the ultimate seriousness of the situation; just as the presence of the root fungi intensifies the effect of drought on the plant and increases its susceptibility to attacks of froghoppers. Possibly the exceptional cases where froghoppers have been said to attack healthy canes could be explained: (1) By the fact that the apparently healthy canes were suffering from drought, sudden alternation of wet and dry periods, unsuitable soil conditions, or defective agricultural practice; and (2) by the fact that the variety of cane grown was in some way unsuited to the local soil conditions.

By increasing the health and vitality of the cane, we might increase its resistance not only to the attacks of froghoppers, but also to the attacks of a number of other insect and fungus pests. In a "Handbook for Planters and Refiners," published nearly forty years ago, there is a statement to the effect that "there can be no room for doubting that these insect and fungus pests have originated in defective systems of culture, improper or insufficient manuring, or unsuitable conditions of climate or soil. Diseases of this kind can only be combated by removing the cause, whatever that may prove to be." This aspect of the problem will be discussed later.

### Summary and Conclusion.

There appear to be two main causes of "blight," namely, the attacks of the froghoppers (*Tomaspis saccharina*) and the attacks of root fungi (*Marasmius* and *Odontia*).

The susceptibility of the cane to the attacks of these root fungi has been shown to be largely due to unsatisfactory conditions as regards the health of the plant and particularly to conditions of drought—physiological or actual. Moreover, this root disease tends to intensify the effect of the water-shortage. It is suggested that a careful analysis of the evidence might also show that the susceptibility to froghopper attack is due to causes which disturb the water balance of the cane, a disturbance which would be even more marked where root disease was present.

The balance in the water content is dependent upon the simultaneous working of the absorption that takes place through the roots and the transpiration that takes place through the leaves; if transpiration is excessive the plant makes too great a demand upon the supply of available water in the soil. The humid climate of Trinidad is, therefore, particularly favourable to the growth of the sugar-cane. A favourable climate can, however, be offset by unfavourable soil conditions. The distribution of the rainfall, the conditions of the soil, the degree of atmospheric humidity, the effect of the disturbance of the water-balance upon the nature of the cell-sap, etc., all need to be taken into account. As regards rainfall and blight, it would appear that: (1) Prolonged periods of drought, or of excessive rainfall; and (2) periods of drought following on spells of excessive wet weather, are both particularly harmful.

In view of the part played by root absorption in the maintenance of the water-balance, a detailed consideration of the root system of the sugar-cane in connection with blight might possibly throw fresh light upon the subject.

A disturbance of the water-balance may also affect the cane's susceptibility to the attacks of insects through its effect upon the physiology of the cane. Is it possible that drought (physiological or actual) or other unfavourable climatic and soil conditions may affect the concentration or constitution of the sugars in the sap in such a way as to render them more attractive to sap-feeding insects?

The problem is extremely complex. We have seen that root disease is dependant upon the weakness and debility of the cane, resulting from unfavourable environmental conditions and from shortage of water; that the root disease thus caused intensifies the effect of this water-shortage by lowering the plant's capacity for root absorption; that the plant, susceptible in any case to attacks of froghoppers



as the result of any disturbance in the water-balance, is rendered even more susceptible as a result of root disease. On the other hand, root disease is said to be due to a lack of vitality in the plant ; a plant attacked by frog hopper is greatly reduced in vitality, and thus the tendency to root disease is increased.

We have considered the interrelation between the absorption of water by the roots and the transpiration of water through the leaves, and the effect of the water content on the physiology of the plant. We must also consider the interrelation between the attacking frog hopper and root fungus, and the cane which is attacked.

Can we decrease the number of attacking organisms, or is it more feasible to increase the cane's resistance to their attack ? In the past the economic entomologist has directed his attention almost entirely to answering the first question ; it is now realised that an answer to the second question is quite as, perhaps even more, urgently demanded. Unhealthy canes are undoubtedly more susceptible to attack than healthy canes, that is, if we use the term " health " in its rightful sense as denoting vigour and the capacity to resist adverse environmental conditions, and not merely luxuriant growth.

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\* Includes an extensive bibliography comprising nearly 150 references.

LARVA OF *Aedes (Ochlerotatus) pulchritarsis*,  
 ROND., VAR. *stegomyina*, STACK. & MONTCH., NOV., FROM  
 TURKESTAN. *originally A.S.*

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*Zootomical Laboratory, University of Leningrad.*

So far as I know the larva of *Aedes pulchritarsis* has not yet been described. Meanwhile, some of the peculiarities of its external anatomy and biology are worth recording.

The adults that I have bred from these larvae have been kindly determined by Mr. A. A. Stackelberg and described in his "Revision of the Mosquitos of U.R.S.S." With his kind permission I take the liberty of citing the description of this new variety from his manuscript.\*

***Aedes (Ochlerotatus) pulchritarsis*, Rond., var. *stegomyina*, Stack. & Montch., nov.**

"It differs from the typical form by the colour of the scales of the head and mesonotum. The head is covered with white and black scales grouped in spots. The mesonotum is covered with blackish-brown or black scales with a longitudinal median stripe of white ones. The transverse bands of the same colour, more or less developed, are placed near the middle of the mesonotum and in the hind third of it. The lateral margins of the mesonotum are covered with white scales. The abdomen and the male hypopygium are similar to that of the typical form. The femur and tibia have as a rule a greater admixture of white scales."

### Description of the Larva.

*Fourth Stage Larva* (figs. 1 and 2).—Head (fig. 1, A) yellow, a little broader than long, much dilated behind the eyes. Antennae pale, quite bare—without spinules (in all stages). The hair-tuft is placed on the upper side and has 3–4 hairs. Beyond the tuft the antennae grow narrow and are slightly curved inwards. The compound eyes are small and occur only in the fourth stage. The hairs on the dorsal part of the head are well developed. Pre-antennal hairs delicate, formed of about 13–16 hairs. Post-antennal hairs much longer, the outer longer than the middle one, the inner in front of the middle. The hair formula is 10, 7, 9–10, 9–10, 7, 10. The mental plate (fig. 1, B) consists of a central tooth, with six on each side of it, which are smaller and close to one another, and four more, situated somewhat apart, which are broader at the base than the first, the terminal ones being smaller than the rest.

The thorax and abdomen are whitish and transparent. The chaetotaxy is well developed; the dorsal tufts of the abdomen are stellate.

The lateral comb of the eighth abdominal segment (fig. 2, A) is provided with 8 teeth (6 or 9–10 may occur as exceptions). Each tooth consists of a blunt spine with numerous lateral spinules at the base. The siphonal tube is dark brownish, more chitinated than the head, about 0.9–1.0 mm. long and 0.3–0.33 mm. broad at the base and slightly tapering from the middle to the apex. The pecten is composed of about 18 teeth closely set to one another. The basal one or two teeth are small. Each tooth is provided with 3–6 basal denticles. The siphonal tuft has 3–4 hairs and is placed a little in front of the middle of the siphon, being a little longer than the breadth of the siphon at the base.

\* I avail myself of the opportunity to reiterate my sincerest thanks to him for it.



The anal segment is a little shorter than its breadth, with a small chitinised saddle extending to the middle of the sides of the anal segment. The lateral hair of the saddle is long and single. The complex of dorsal tufts consists of two long outer bristles, a little longer than the anal gills, and of two considerably shorter (half as long as the gills) 5-haired inner tufts. The anal brush is reduced and consists of only four pairs of tufts in the barred area (the last pair being half as long as the other) and of 2 pairs of tufts situated before them. All these tufts are 2-haired.

The most important feature is the length of the anal gills (fig. 2, A). They attain one-quarter of the length of the whole body of the full-grown larva (1.8-2.0 mm.). They are sausage-shaped and rounded at the tip. So far as I know this is the only instance of such long anal gills occurring in larvae of palaearctic species. It is interesting to mention that this development of the anal gills is in this case combined

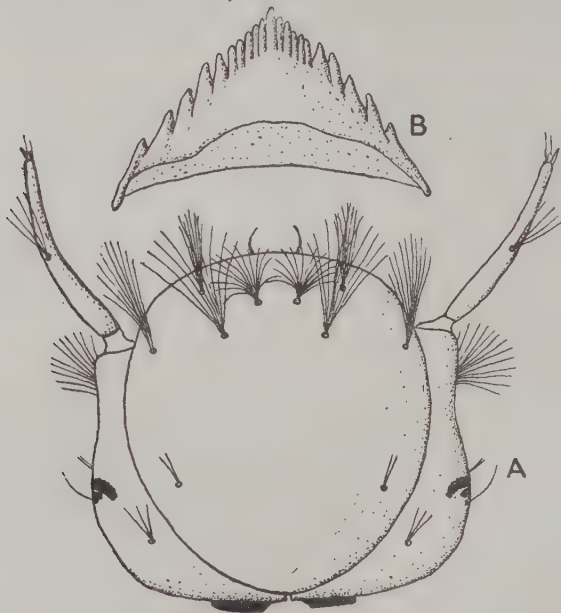


Fig. 1. Fourth stage larva: A, head; B, mental plate, more highly magnified.

with a reduction of the anal brush. Direct observations of the mode of locomotion of the larvae of *A. pulchritarsis* indicate that in this instance the locomotive function is transferred from the anal brush to the anal gills. When swimming the larva turns the complex of dorsal tufts downwards, so that they are situated between the upper pair of anal gills, turning in the meantime the anal brush upwards between the lower pair of anal gills. The corresponding muscles, as well as the chitinised process at the base of the dorsal tufts to which these muscles are fastened, are much better developed than in larvae of other species. Thus, the dorsal tufts and the anal brush play the part of supports to the anal gills.

Apparently the same may be observed in the larvae of *Stegomyia*, the corresponding organs of which are in similar relationship.

I do not agree with the opinion of some authors that a reduced anal brush is only found in larvae breeding in small containers, which are, therefore, in no need

of well developed organs of locomotion. This reduction is always combined with some kind of equivalent. A definite volume of water is required for the normal development of a larva, and its agility in these limits has no relation to the entire volume of the reservoir. Under natural conditions the movements of the larva are confined within a relatively small area.

The structure of the stigmal plate\* (fig. 2, B) is in some points derived from the typical *Ochlerotatus* plate. It differs from the latter in the following characters: (1) In the structure of the organs on the middle flaps. Its base is not bilobed, as it is in the majority of *Ochlerotatus*, but is extended backwards in the direction of the stigmal processes of the lever ("stirrup-shaped piece" of Howard, Dyar & Knab,

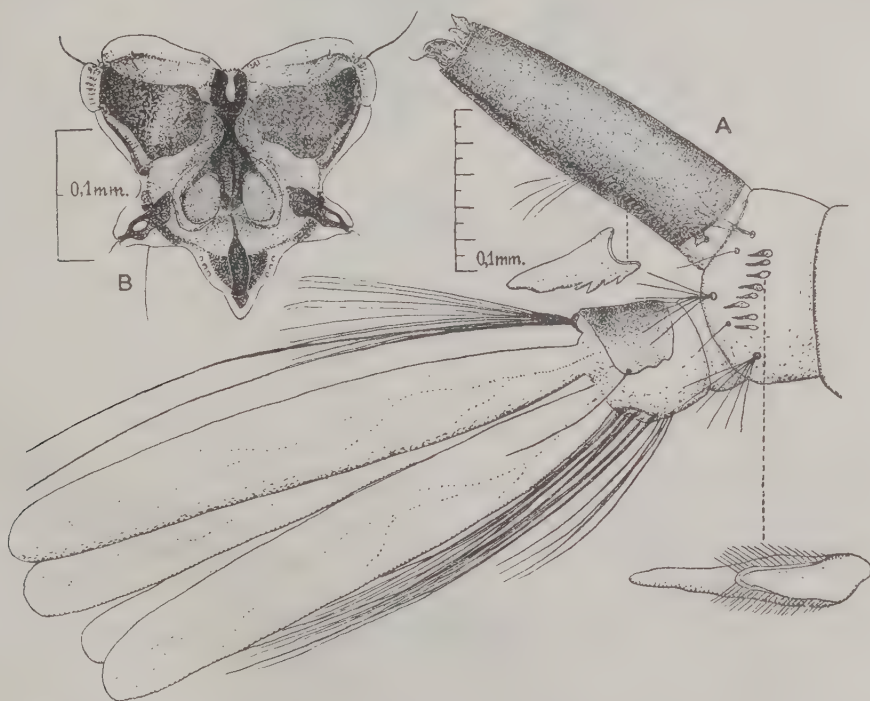


Fig. 2. Fourth stage larva: A, end of abdomen, with comb and pecten teeth more highly magnified; B, stigmal plate, open.

and of Wesenberg-Lund). (2) The upper surfaces of the hind flaps are attached to the hind process of the lever behind the base of its terminal bifurcation. In all the other *Ochlerotatus* larvae with which I am acquainted this attachment is situated in front of it. (3) The shoulders of the lever and their extensions (the stigmal processes) are fastened not to the outer side, as we find in other larvae, but to the inner side of the stigma.

The stigmal plates of the third (fig. 3, B) and second stage larvae possess both the first and the second of these properties and have a peculiar swollen stigma, which

\* Some special articles concerning the structure of stigmal plates in larvae of *CULICIDAE*, viewed anatomically and systematically, are to be published shortly.

is a specific character of these stages in all the larvae of CULICINI. The stigmal plate of the first stage larvae (fig. 5, B) is only remarkable for its very long hairs "e" (according to Martini's classification, 1923) on the hind flaps.

*Third stage larva* (fig. 3).—Head about as long as broad. Antennal tuft 3-haired. Compound eyes absent. Pre-antennal hairs 7-haired. Post-antennal hair formula : 6, 4, 5, 5, 4, 6. The lateral comb of the eighth abdominal segment with 8 teeth.

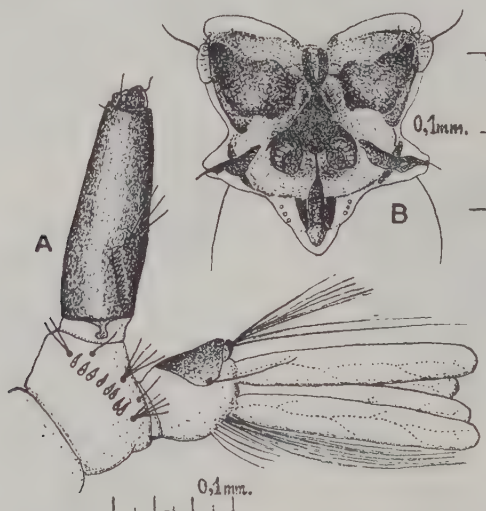


Fig. 3. Third stage larva : A, end of abdomen ; B, stigmal plate, open.

This character does not change with the age of the larva. Only first stage larvae have 4 teeth in the comb. The siphon is 0.5–0.6 mm. long and 0.15–0.2 mm. broad at the base. The number of pecten teeth is larger than in the fourth stage and reaches 20–22. The siphonal tuft is 3-haired. The anal gills are relatively shorter,

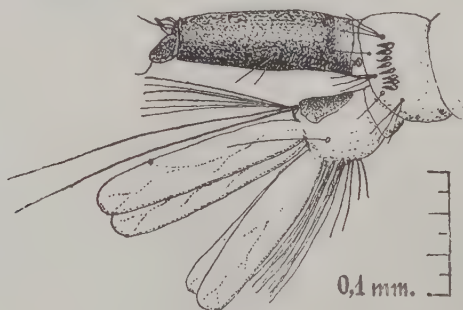


Fig. 4. Second stage larva : end of abdomen.

only a little longer than the siphon (0.58–0.65 mm.). The formula of the dorsal tufts of the anal segment is 1, 3, 3, 1. The anal brush consists of 3 pairs of 2-haired tufts in the barred area (the last pair half as long as the rest) and of 2 pairs of much shorter single hairs before them.

*Second stage larva* (fig. 4).—Head about as long as broad. Antennal tuft 2-haired. Pre-antennal hairs 8–10-haired. Post-antennal hair formula: 5, 4, 5, 5, 4, 5. Lateral comb consists of about 8 teeth. The siphon is 0.4–0.45 mm. long and 0.13–0.15 mm. broad at the base. The base of the siphon is not entirely chitinised. The siphonal tuft is 2-haired. The pecten is provided with 12–16 teeth. The anal gills are as long as the siphon or a little longer (0.45–0.55 mm.). The formula of the dorsal tufts of the anal segment is 1, 3, 3, 1. The anal brush consists of 3 pairs of 2-haired tufts in the barred area and of two pairs of single hairs before them.

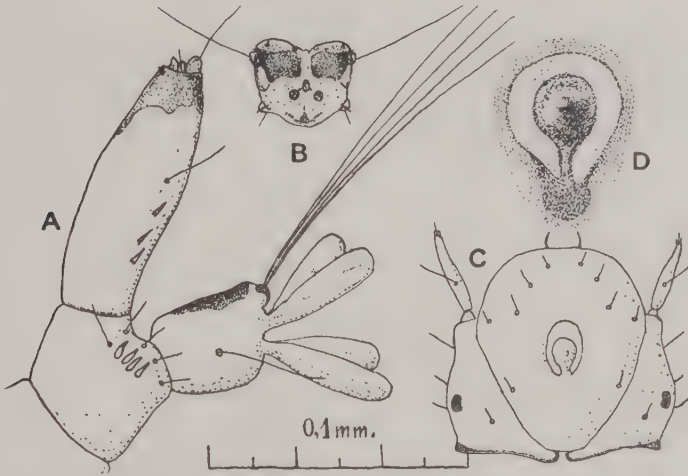


Fig. 5. First stage larva: A, end of abdomen; B, stigmal plate, open; c. head; D, egg-burster; (B and D more highly magnified).

*First stage larva* (fig. 5).—Head with a well developed egg-burster (fig. 5, D). All the hairs are single. The comb of the eighth abdominal segment is provided with 4 teeth. The siphonal tuft consists of a single hair, placed beyond the middle of the tube. The pecten consists of 3–4 plain teeth. The anal gills are half as long as the siphon—about 0.15 mm. The formula of the dorsal tufts of the anal segment is: 1, 1, 1, 1. Anal brush absent.

### Biological Notes.

The larvae of *A. pulchritarsis* breed exclusively in tree-holes. These tree-holes are periodically flooded when water is released from irrigated fields. Therefore, they are to be found only in localities where conditions of topography and irrigation permit the existence of such breeding places. This is the cause of the very localised distribution of this species in Turkestan. Dr. L. M. Issaijeff kindly informed me (in conversation) that in the years 1922 and 1923 *A. pulchritarsis* had been common in the neighbourhood of Old Bokhara. In 1925 I could not find there a single specimen; the species has completely disappeared from that country. During these last 3 years, in connection with an anti-malaria campaign, swamps have been drained there and the use of water by the local population and the irrigation of the fields has been regulated. In consequence of these measures the hollows of trees have not been flooded any more and this has been the cause of the disappearance of *A. pulchritarsis* from Old Bokhara.



*A. pulchritarsis* winters in the egg stage. The larvae hatch in spring (end of March to beginning of April in 1925), and there are several generations during the summer. The number of generations (not below 3) depends on the periodical flooding of the tree-hollows, which may become completely dry in summer during intervals between the irrigations. Deposited eggs, like those of *A. (Stegomyia) argenteus*, resist such drying perfectly well.

At Katta-Kourgan, 19.vii.1925, I filled with water some tree-hollows that had been dry for about a month, and two days later they swarmed with newly-hatched larvae of *A. pulchritarsis*, and the water became dark brown in colour; 36–48 hours later these larvae moulted into the second stage, and two days later the next moult began.

The larvae are very resistant to unfavourable circumstances of environment. In the middle of April I received some second and third stage larvae of *A. pulchritarsis* from Samarkand and Katta-Kourgan, corked in narrow glass tubes. Some of the larvae in them successfully completed their development with only a delay of about 3 weeks. No other larva which I know could have survived and also completed its development under similar conditions.

Edwards (1921) in his "Revision of the Mosquitos of the Palaearctic Region." (p. 271) writes: "As has already been pointed out by Christophers,\* tree-hole larvae of different genera of mosquitos commonly show three forms of modification: (1) A reduction of the hairs on the head and especially of the small bristles on the antennae; (2) an increase and enlargement of the hairs on the thorax and abdomen; and (3) a development of chitinous structures on the last few abdominal segments."

The larvae of *A. pulchritarsis* do not bear out these statements. The chaetotaxy of the head (fig. 1) is well developed. The spinules on the antennae are absent, as in *Anopheles plumbeus*, but they are also absent in *Theobaldia longiareolata*, the larvae of which are not tree-hole breeders. The development of the chaetotaxy of the body does not exceed the normal. Chitinous structures are absent. I have received from Dr. Rukhadze from Sukhum and Gagry (Black Sea coast of the Caucasus) some larvae of *Anopheles plumbeus*, which breed there not in tree-hollows but in open reservoirs. Their structure and chaetotaxy are the same as that of the tree-hole breeders.

Moreover, the larvae of *A. funestus*, Giles, have larger chitinised structures on the abdominal segments and are not tree-hole breeders. The development of these structures in *Anopheles* larvae is closely connected with the abdominal musculature. Sections show that they are the places of insertion of the oblique abdominal muscles, thus playing a considerable part in the locomotion of the larvae.

I consider the points mentioned by Edwards to be merely a fortuitous association of characters in a few tree-hole larvae. In the case of *A. pulchritarsis* the influence of the specific breeding-place is seen in a relatively late development of the compound eyes, as well as in a peculiarity in the constitution of the chitinous cuticle, which is exceedingly tough and impervious as a consequence of the high salt concentration in these breeding-places.

### Systematic Notes.

In the hypopygium of the male and other adult structures *A. pulchritarsis* is closely related to *A. mariae* and *A. zammittii*. The systematic position of the larva is different. The publications of Dyar, de Meijere and others indicate that systems based either on adult or on larval characters only are not likely to be in agreement, the evolution of adults and larvae often taking different courses. There is nothing

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\* To my great regret I am not acquainted with Christophers' paper.

extraordinary in the fact that the larvae of *A. pulchritarsis* possess comparatively more characters belonging to the subgenera *Finlaya* and *Stegomyia* than do those of *Ochlerotatus*, and particularly of *A. mariaae*.

The following characters: (1) General structure of the head; (2) absence of antennal spinules; (3) structure of the mentum (identical with that of *Finlaya echinus*); (4) structure of the lateral comb; (5) arrangement of the pecten teeth (similar to that of *Finlaya geniculatus*); (6) a slightly developed siphonal tuft; and (7) the length of the anal gills, resembling those of *S. argenteus*, bring our larva near to the larvae of *Finlaya* and *Stegomyia*, and make it an intermediate connecting link between the larvae of these subgenera on the one hand and those of the subgenus *Ochlerotatus* (through *A. mariaae*) on the other.

I regret that I am unacquainted with the structure of the stigmal plates in *Finlaya* and *Stegomyia*, but, nevertheless, I venture to predict that in this character too *A. pulchritarsis* will prove to have more features in common with *Finlaya* and *Stegomyia* than with *Ochlerotatus*.

Old Peterhof, near Leningrad,  
5th July, 1926.

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## COLLEMBOLA INJURING LEAVES OF MANGOLD SEEDLINGS.

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(PLATES XIV-XV.)

During investigations on the economic position of Collembola a significant attack on mangolds by one species of this group occurred at Rothamsted in the classical mangold field known as Barn Field. The particular species involved was *Bourletiella hortensis*, Fitch (*pruinus*, Tullb.). Although the economic position of Collembola has not, as yet, been fully established, this member of the order can claim priority in the list of previously reported economic species. The first British record of injury probably by this species is that of Miss Ormerod<sup>1</sup> in 1894, when she reported leaf damage to turnips in Scotland. Since then British records include as host-plants sweet peas, beans, radishes, lettuce, mangolds<sup>2</sup> and soy beans<sup>3</sup>. Reports from America confirm the economic position of this species, and in Canada Macnamara<sup>4</sup> states "the list of plants it is known to injure reads like an index to a seedsman's catalogue: beans, beet, cabbage, cantaloupes, carrots, clover, corn, cucumber, kale, lettuce, mangolds, onions, peas, potatoes, radishes, rye, spinach, squash, tobacco, tomatoes, turnips, violets, watermelons, wheat, wild cucumber."

Records of damage to mangolds by this species have appeared in the Monthly Reports of the Ministry of Agriculture during the last few years. Several of these refer to the so-called disease known as "strangle" to which the mangold crop is liable at a stage of growth when the roots are well above ground. This damage, it appears, may be due to several causes, each with its specific difference, but *Bourletiella hortensis*, as previously recorded,<sup>5</sup> is certainly one of the agents concerned.

The particular attack at Rothamsted occurred during the first week of June 1926, and was of the nature of leaf damage at a stage when the roots were not above ground. Barn Field, situated about 400 feet above sea-level, has a slight slope with a north aspect, and the soil is a heavy clay with a fair proportion of flints. This experimental field has grown mangolds continuously since 1876, when it was divided up into the present number of experimental plots varying in manurial treatment. Apart from an attack of *Atomaria linearis* (pigmy beetle) in 1922, the field has generally been free from serious insect damage.

The variety of mangolds Yellow Globe had been sown on 7th May 1926. A quantity of seed had been soaked in water and afterwards mixed with an equal amount of dry seed; the mixture was sown at the rate of 8 lb. per acre. This procedure ensures a double germination, which is frequently beneficial in the case of insect attack or of drought. This year the mangolds were sown on the ridge.

### Nature of Damage.

The attack was reported on 31st May by Mr. C. Heigham, Farm Director, and investigations were immediately commenced. The field at this period was remarkably free from weeds. A search was made for wilting plants suggestive of attack by *Atomaria linearis*, but only a negligible number were found, together with a few isolated examples of the beetle.

Practically 100 per cent. of the mangold seedlings showed leaf damage (Pl. XIV, fig. 1). Flea-beetles were suspected of being the cause, but a careful search for these showed that they were almost entirely absent. Closer examination of damaged



plants and the surrounding soil, however, revealed the presence of enormous numbers of small black Collembola (springtails), the species being *Bourletiella hortensis*, Fitch (Pl. XIV, fig. 2). Practically every plant was infested with them (to give a farmer's expression of his observations, they were "smothered" with them). Examination with the hand lens permitted one to observe the damage being done. Doubt has been expressed from time to time regarding the ability of these small insects to cause such damage. Individually, this may not be possible, but the habit of this species of feeding in groups accounts for the comparatively extensive injury. This habit has been noted by the writer in a previous investigation in North Wales<sup>5</sup> and was frequently noted in the present observations. The groups varied in number of individuals, but as many as 17 were observed busily engaged in enlarging a perforation. The curved damaged area of the plant on the right hand side of the lowest row in the illustration (Pl. XIV, fig. 1) was seen to bear 13 individuals along its border. This habit has evidently been formed owing to the attraction of exuding plant juices. It should be emphasised that the nature of the damage is two-fold, for in addition to the actual biting and enlarging of the damaged area, wounds are kept constantly open and excessive bleeding ensues.

### Field Treatment.

The damage to the crop was such that it was necessary to carry out a method of control on a large scale. Observations were made at 6.30 a.m. on 1st June; the field conditions in the early mornings being more constant for comparative work. The soil was damp; the day bright, with a slight breeze blowing. The distribution of Collembola over the different experimental plots appeared to be proportional to the leaf area. Counts were taken on the dunged plot (No. 1). Attempts to count plant or leaf infestation proved unsatisfactory, since the Collembola jumped at the slightest disturbance. The following method was therefore adopted. A glass cylinder measuring  $3\frac{1}{2}$  inches in diameter and 6 inches in height was placed quietly but quickly over a group of plants—four being the number aimed at. The Collembola on the plants were knocked off on to the soil within the cylinder. The numbers present on this unit area (approximately 9 sq. inches) were then counted by visualising the centre of the surface and counting in a clockwise direction along the "radius." Duplication, where necessary, was made by returning in an anti-clockwise direction. Twenty preliminary random counts were made with the following results—average numbers present per unit area 19.7, maximum 41, minimum 13. The average number per acre works out at about 1,500,000

The first treatment was with paraffin-soaked sacks, which were trailed behind a flat horse-roller. Observations after treatment revealed the repellent effect of the paraffin, since few Collembola were observed on the plants and those on the soil were extremely active. Heavy rain fell during the night and the following day, and counts were taken again at the same hour on 3rd June, when atmospheric conditions were somewhat similar. It was very evident that the repellent effect of the paraffin had been washed off by the rain, for 20 counts gave an average of 21 (max. 44, min. 10) individuals per unit area.

On 4th June a further attempt at control was made. The ability of the Collembola to jump was made use of and the method adopted was that of catching the insects on tarred sacks, particulars of which will be described later. This method of actually seeing the number of insects killed more or less obviated the necessity of controls and permitted uniform treatment of the whole area, which was essential on the experimental field. Sixty random counts made previous to the treatment gave the following results: Average, 26 (max. 55, min. 13) individuals per unit area.

Examination of the tarred sacks after use revealed enormous numbers of Collembola. For demonstration purposes it was decided to replace a tarred sack

by one coated with white varnish. Although, perhaps, this was not so successful as the more adhesive tar, the "catch" which was observed after treating two rows (one-eleventh of an acre) convinced even the previously sceptical farm-workers that their efforts were a great success. A portion of the painted sack is illustrated (Pl. XV, fig. 1). The number of flea-beetles caught was very low, thus confirming the observations regarding the comparative scarcity of these pests. Slight rain fell during the evening, and further counts were made in the early morning of 5th June, when the soil was damp, and bright, still, conditions prevailed. A very marked reduction in the numbers of the Collembola was apparent and was confirmed by the following results of 40 counts of individuals per unit area—average 5.4 (max. 19, min. 0). The presence of a little tar on some leaves suggested that there was a repellent effect in addition to the numbers removed.

Another 40 counts of individuals per unit area were made at the same hour on 7th June; the results were as follows: Average, 8.4 (max. 15, min. 2). Although it was possible to find a few individuals on the plants after treatment, no instance of the habit of collective feeding was observed. The young mangolds grew very favourably, the leaf damage being obviously reduced to a minimum. In the opinion of the Farm Director, a continuance of the full attack for another day or two would have destroyed the great majority of the young plants and so have led to a complete failure of the crop. In so far as this was prevented and the surviving plants were given an opportunity to recover and to develop new leaf areas, the treatment may be said to have saved the crop.

In improvising apparatus to deal with this pest, farm implements naturally received first consideration. The best of several attempts, and the one used successfully on Barn Field, was that seen on the right in Plate XV, fig. 2. It consists of two Planet hoes fastened together by long crossbars covering two ridges in width. A sack, tarred over the region 9 inches from the bottom, was hung so that the tarred surface just trailed above the two ridges. A similar sack, hanging perpendicularly, was placed behind. It would have been possible for one man to work this, but two proved more effective. The contrivance was pushed—this method being essential owing to the habit of Collembola of jumping when disturbed by a shadow. The sacks were re-tarred at intervals. The cost of the treatment was approximately 1s. 6d. an acre. Other contrivances used included two bicycles fastened side by side by long axles on which the sacks were hung. A Jacob's seed barrow was also adapted. While the latter covered 5 rows and thus reduced the cost to 8d. an acre, difficulty was experienced, especially against a strong wind, in keeping it horizontal.

It was felt desirable, however, to have a machine which could be worked by a boy and which might be useful in the case of other attacks by springtails or by flea-beetles. In making this machine it was necessary to bear in mind that Collembola can jump to a height of 2-3 inches, and also that while some jump on the approach of a shadow, others require to be touched. In its final form, as seen on the left of Plate XV, fig. 2, it consists of a pair of old bicycle wheels with an iron axle 25-27 inches long. Two L-shaped brackets—adjustable for different heights of ridges and for level ground—are bolted to the axle, the horizontal arms (20 inches) project forwards and hold on the underside an arch-shaped wooden box. A piece of strong string or thin wire hangs loosely across the inside of the archway and thus trails over the plants just in front of the sacking which forms the back of the arch. The entire box and sacking are smeared with tar or other adhesive substance. This can be best done when the machine is turned over on one wheel. The whole contrivance is pushed by means of a fairly long handle; the roof of the box is kept horizontal at a height of 2-3 inches from the soil. If necessary this implement can be enlarged by increasing the length of the axle and the number of boxes. The cost for the single arrangement worked by a boy is about 1s. an acre.

This machine has also been used with success against flea-beetles, but a slight adaptation is necessary. It was found that while numbers were caught on the inside, especially the roof, of the archway, others jumped and alighted on the top of the box. A piece of 3-ply wood, smeared with the adhesive substance, was therefore fixed in a slanting position on the top of the box. In this way the number of flea-beetles caught was considerably increased. Certain differences in treatment of the two pests should be noted: Flea-beetles jump higher than *Collembola*; and while bright, sunny, dry weather is ideal for flea-beetles, dull, warm and damp weather is more favourable for springtails.

Before passing to laboratory experiments it should be added that other local reports of similar attacks have been received, and a crop of mangolds at Woburn is stated to have suffered considerably from *Bourletiella hortensis*. Other host-plants noticed in the field include grounseel, goosefoot and red-shank.

### Laboratory Observations.

Observations in the field by the Farm Director, the writer, and others were so convincing that it seemed unnecessary to prove, by controlled experiments, the ability of *B. hortensis* to cause such damage. Pots with insect-free soil were, however, set up in the insectary and Yellow Globe mangolds sown. The pots were covered with large glass cylinders, the tops of which were closed by fine muslin. After the seedlings had appeared, specimens of *B. hortensis* were collected in the field and transferred to the experimental pots; control pots were kept. It was at once apparent that this species disliked caged conditions, for they became very active, jumping and moving about rapidly and eventually congregating on the muslin on the top of the cage. This they did to a certain extent throughout the experiment. After two days, however, the young mangolds were seen to be attacked, and perforations similar to those observed in the field were visible on the leaves. Specimens of these leaves are figured in the middle row in Plate XIV, fig. 1. The extent of the damage is not nearly so marked as was the case in the field, and at least two reasons can be assigned for this. The unsettled condition of the *Collembola* under caged conditions prevented the collective habit of feeding, so that no instance of this habit, which largely accounts for the extensive damage in the field, was observed. Further, under these experimental conditions the damaged areas caused by the insects quickly dry up and there is no attraction by exuding plant juices.

I am greatly indebted to Dr. A. D. Imms for suggestions and advice during this investigation, and to Mr. C. Heigham for his assistance and co-operation in connection with the field work.

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Fig. 1. Damaged mangolds taken during an attack by *B. hortensis*.



Fig. 2. *Bourletiella hortensis*, Fitch (*pruinosis*, Tullb.)  $\times 500$ .







Fig. 1. Portion of painted sack used in control, showing great numbers of trapped *B. hortensis*.



Fig. 2. *Right.* Improved machine carrying tarred sacks, effective in trapping *B. hortensis*.  
*Left.* Machine recommended for use against springtail attack, and easily adapted for flea-beetles.



# THE CYPRUS PROCESSIONARY CATERPILLAR (*THAUMETOPOEA WILKINSONI*, TAMS).

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(PLATES XVI-XVIII.)

## Introduction.

There has long been known to occur in Cyprus a species of processionary caterpillar attacking the pine; it remained for the present writer, in 1924, to breed through the adult moths, and these were later determined by Mr. Tams, of the British Museum, to be a new species of the genus *Thaumetopoea* (formerly *Cnethocampa*), of the family NOTODONTIDAE, which he described under the name *T. wilkinsoni* (Bull. Ent. Res. xv, 1925, p. 293).

The allied species of importance number seven, and it seems advisable to set forth here such points in their life-histories as are relevant.

(1). Of all the allied species the most important is probably *Thaumetopoea pityocampa*, Schiff. This insect abounds throughout temperate Europe and in the Mediterranean basin, attacking all species of pines. As a rule the adults fly in July and early August, and the eggs, which are laid in cylindrical masses, are covered by the female with scales from her anal tuft. Cecconi states that the masses contain from 100 to 150 eggs; Calas, on the other hand, puts the number at from 200 to 600. The incubation period is about 20 days. The larvae construct for themselves in the trees a silken nest with strong walls, to which they retire for rest during the day, for moulting, and for hibernation. The larvae hibernate during all the cold weather, that is to say, from October to March. There are three moults. The mature larva is 30-40 mm. long, and 4-5 mm. wide. The larvae when walking go in single file. Pupation takes place in May, in the ground, at a depth of about 10 cm., in an oval cocoon 15-25 mm. in length. The pupal life varies as a rule between the extremes of two and three months. Some pupae, however, do not yield adults in the year of pupation, but hibernate until July in the following year.

The following parasites and predators have been recorded:—

Egg parasites: *Schedius pityocampae*, Mercet, *Tetrastichus vinulae*, Thoms., and *Trichogramma semblidis*, Aur., all of which are of considerable importance.

Larval parasites: The Ichneumonid, *Anomalon latro*, Schr.; the Diptera, *Tricholyga grandis*, Zett., *Lydella lepida*, Mg., and *Ceratochaeta secunda*, B.B., and the fungus, *Botrytis bassiana*. In addition the Alpine, or Mountain, Crow, *Corvus pyrrhocorax*, is recorded as feeding in winter on half-grown larvae.

(2). *Thaumetopoea processionea*, L., is the oak processionary and is distributed throughout Central Europe, Spain, Italy, Bulgaria, Turkey, and Morocco.

The adults are on the wing from the middle of August until early September, and the eggs are laid on the smoother portions of the bark of the oak in a regularly formed patch, each patch containing from 100 to 200 eggs. The eggs are cemented to the bark and are covered by the female with the scales from her anal tuft. The eggs hibernate and hatch in early May. The larvae gradually construct for themselves a nest in which they live gregariously during the daytime, emerging at night to feed. The nests may attain the size of 1 metre in length by 20-30 cm. in breadth. The full-grown larva reaches approximately 3-4 cm. in length. Pupation, which



takes place about the middle of July, occurs within the communal nest, each caterpillar constructing for itself a separate cocoon. In length the pupa never exceeds 15 mm. The duration of the pupal stage averages 2-3 weeks.

The following parasites have been recorded :—

#### ICHNEUMONIDAE.

*Anomalon amictum*, F.  
*Cubocephalus germari*, Rtzb.  
*Pimpla examinador*, F.  
*Pimpla instigator*, F.  
*Pimpla processioneae*, Rtzb.

#### BRACONIDAE.

*Perilitus brevicornis*, Rtzb.  
*Perilitus ictericus*, Nees.

#### CHALCIDIDAE.

*Pteromalus processioneae*, Rtzb.  
*Pteromalus puparum*, L.

#### TACHINIDAE.

*Ceratochaeta caudata*, Rond.  
*Compsilura concinnata*, Mg.  
*Epicampocera crassiset*, Rond.  
*Carcelia excisa*, Fall.  
*Pales pumicata*, Mg.  
*Pales pavid*, Mg.  
*Paraxorista lucorum*, Mg.  
*Phorocera assimilis*, Fall.  
*Phryxe vulgaris*, Fall.  
*Zenillia libatrix*, Panz.  
*Zenillia macrops*, B.B.

The following predators are also recorded : The beetle, *Calosoma sycophanta*, L., and cuckoos, woodpeckers, tits, wrens, and bats.

(3). *Thaumetopoea pinivora*, Treit., another pine processionary, appears to be recorded only from Southern Sweden, Germany, and West Central Russia, thus seeming to be limited to temperate Northern Europe.

It would seem that from those eggs which are laid in May and June caterpillars hatch in early July, pupating in the autumn, thus giving one generation a year, unless such pupae hibernate through into the 3rd, or even 4th year, as is sometimes the case. The development of *T. pinivora* is, however, very irregular, since eggs which are laid by late-flying females in July and August do not hatch until April or May in the following year, such larvae pupating in September and emerging as adults in the following July. The eggs are laid almost invariably on *Pinus sylvestris*, and, as in *T. pityocampa*, in cylindrical masses, each mass containing from 80 to 150 eggs. The larvae do not make true nests, as in the case of the two preceding species, but gather together in bunches in the forks of the tree. The mature larva is about 4 cm. long. The processions are generally in single file, although processions of two and three lines broad may occur. Pupation takes place in the ground, the cocoons being all closely pressed together. In length the pupae average 15 mm., and the cocoons 20 mm.

The following parasites have been recorded : The Diptera, *Dexodes macheiropsis*, B.B., *Pales belliera*, R.D., and *Lydella nigripes*, Fall.

(4). *Thaumetopoea herculeana*, Rambur, occurs in Spain and Tunis, attacking various species of *Geranium*, cereals, and all manner of wild and cultivated plants.

(5). *Thaumetopoea solitaria*, Freyer, is distributed about European Turkey, Asia Minor, and Syria. The adult emerges in September.

(6). *Thaumetopoea cheela*, Moore, occurs in Northern India.

(7). *Thaumetopoea jordana*, Stdgr., occurs in Palestine.

### Life-history of the Cyprus Processionary Moth.

*Imago*.—In the plains, that is to say at an altitude of 500 feet above sea-level, the moths begin emerging about the end of August and continue until about the end of the first week in October. From all the many cages employed in the writer's insectaries no moth has emerged before 29th August, and none after 7th October.

That emergence takes place in the field outside these dates is, however, more than probable. The height of emergence in the insectary was found to be between 9th and 16th September, but far too few moths have been bred through to determine these dates with any exactitude. No particular time of day was observed to be preferred by the moths for emergence.

The male is a strong flier. The female, however, although capable of good flight, would appear to prefer walking; she is an ungainly insect, her large abdomen, heavy with eggs, being out of proportion to her wings. The female is larger than the male, and both sexes seem to be attracted by artificial light, but not strongly so.

*Ova*.—From the behaviour of adults in captivity it would appear that oviposition takes place fairly soon after emergence. The exact period of time that elapses between emergence and oviposition has, however, not been definitely determined, but it can certainly be as short as ten days, for on 12th September 1925, and on the nine succeeding days, newly-emerged adults of both sexes were released into a new cage, and on the night of 21st September oviposition was observed, this being the only egg-mass obtained from moths under control. In the plains, therefore, oviposition for the season 1925–26 would appear to have commenced about 9th September and to have continued until about 17th October; the experiments, however, were not on a sufficiently large scale to warrant the assertion that these dates are exact.

The eggs are laid in cylindrical masses round the growing pine needles, generally round a single needle, but often round a pair, while the writer has observed cases where the mass was laid round a bunch of three needles, and, in one instance, round a thin twig of the pine tree. The eggs are pearl-coloured, and in shape they may, perhaps, be best described as an inverted truncated hexagonal pyramid, but with the apex of the egg slightly convex. The extreme altitude of the egg, that is to say from the basal attachment to the apex of the rounded dome, is just short of 1.0 mm. In plan, the egg is an equilateral hexagon slightly rounded at the corners, with the sides measuring at their greatest length 0.6 mm. The figure is, however, slightly and regularly compressed, so that one axis measures 1.3 mm. in length and the distance between the only pair of parallel and opposite sides is barely 1.0 mm. The areas of attachment to the needle are very irregular as to size, but the average length of the longitudinal axis is probably in the neighbourhood of 0.6 mm.

The eggs are very regularly laid in rows; there are generally six or seven longitudinal rows in each cylinder, but occasionally there are eight and also, but more rarely, five; and in addition it sometimes happens that one portion of the cylinder exhibits a different number of rows from the other portions. The eggs are so laid that the longer axis, in plan, is transverse to the longitudinal axis of the needle. The whole mass of eggs is carefully covered by the female with the light buff scales from her anal tuft, which are laid in tile formation, only the bases being cemented on to the eggs (Plate XVIII, fig. 3). The length of these cylinders varies, naturally, in accordance with the number of eggs contained and the number of longitudinal rows; an examination of fifty masses gave as the maximum length 3.8 cm., and as the minimum 1.1 cm., with an average of 2.6 cm., while the average breadth of the cylinders was 3.3 mm. An examination of these same fifty masses showed a maximum of 258 eggs to a mass, and a minimum of 66, with an average of 150.

The oviposition of the one egg-mass obtained from adults under control (mentioned above) was completed by the morning of 22nd September, and the dates on which the eggs hatched are as follows: 23 larvae hatched on 4th November, 20 on 5th, 27 on 6th, 29 on 7th, 15 on 8th, 1 on 9th, and 2 on 10th. The longest period of incubation was thus 49 days and the shortest 43 days. In the case of a number of egg-masses collected in 1924 most of the larvae hatched between 27th October and 6th November, and in 1925 between the 23rd and 30th October.

*First Larval Instar.*—The young larva effects its escape by eating an irregularly round opening in the apex of the egg. On first emergence it measures in length when at rest only 2.5 mm., and when extended only a little over 3.0 mm. The head, when viewed from above, is about 0.8 mm. long and the same in width. The prothoracic segment, when viewed from above, is about 0.6 mm. broad, the mesothoracic 0.5, and the metathoracic and abdominal segments 0.4 mm. The head, which is the most conspicuous part, is strongly chitinised, shining black, and clothed with a few slender light brown hairs, which project forwards. The thoracic and abdominal segments are bright yellow in colour, but this is toned down considerably by a number of hair-bearing warts and spots, while in addition the greater portion of the dorsum of the prothorax appears as a dark brown, chitinised plate.

On each side of the apex of the dorsum of the abdominal segments 1–9 is exhibited a comparatively large triangular or pear-shaped spot. These spots vary considerably in colour, in some forms being of a red so pale as to be hardly discernible against the yellow of the remainder of the body, and in others of a deep brown-red. From each of these spots there spring two, three, or four, but generally four, black, bristly hairs about 0.2 mm. long.

Extending laterally right across the meso- and metathoracic and the nine anterior abdominal segments, and spaced so regularly on each segment as to form dotted longitudinal lines on the body, are smaller red-brown spots, ten to each segment, so placed that the 5th and 6th of each segment are adjacent to, and in some forms completely coalesce with, the posterior angles of the two respective triangular spots mentioned above. Of the remainder of these spots the 1st and 2nd, and the 9th and 10th, are situated below the two lines of spiracles respectively, the 3rd and 4th and the 7th and 8th being equally spaced between the 2nd and 5th and the 6th and 9th respectively. The 1st and 10th are more closely approximated respectively to the 2nd and 9th than are the other spots in these lateral series; in some forms they almost coalesce.

From each of these small spots there springs, in the case of those on the abdominal segments, one long white hair; on those spots, however, on abdominal segments 1 to 8, inclusive, which coalesce with the triangular spots (*i.e.*, spots nos. 5 and 6) no hair is borne. From the spots on the meso- and metathoracic segments there spring two, three, or four long white hairs, with the exception that spots nos. 2, 4, 7, and 9 bear only one.

The prothorax also exhibits these small spots as described above, corresponding to nos. 1, 2, 3, 8, 9, and 10; these also bear long white hairs, nos. 1, 3, 8, and 10 having three or four, and nos. 2 and 9 one only. The chitinised plate of the prothorax also bears long white hairs.

All these white hairs are mostly 0.5 mm. in length, but many, especially those borne on the thoracic and the 9th abdominal segments and those springing from spots which are situated nearer to the apex of the dorsum of the other abdominal segments, extend to as much as 1.0 mm.

Immediately on emergence the young larvae proceed in search of food, and even at this early stage in their lives the processional habit is very marked, for strings consisting of two, three, four, or even of a greater number of these small creatures may be observed moving from off the egg-masses. However, they do not go very far, since they settle down on, and commence eating, the first pine needle that they encounter in their march; the needle around which the egg-mass was laid is never touched, however, anyway at this stage. Gregariousness also is already very marked, for it is noticeable that larvae of only one or two days of age congregate together towards the bases of the needles, while within five days of hatching, definite, small, fine, transparent, silken nests are formed, almost invariably, it may be remarked, at the points of juncture of the needles with the thin shoot.



Only the epidermis of the needle is eaten by these young larvae, and, chiefly, only that of the basal half of the needle. The result is curious, for needles so attacked bend right over, having been rendered top-heavy. Of many needles, however, the epidermis is completely eaten away; these then assume all sorts of twisted shapes, but rarely, if ever, fall. The colonies of young larvae may be found fairly easily by searching for these twisted, brown, dying needles. In Plate XVI, fig. 1, some of these needles are clearly exhibited.

As soon as all the available food within a small limited area has been consumed, the young larvae migrate. In migration they may move only a few inches, or some feet, and in the case of the first instar larvae they then settle down as before to make their little nests and consume the epidermis of a new group of needles. This migration is typical of the first three instars of this insect, and as many as six complete nests, with the same number of migrations, were observed for one colony during its three earlier instars, before it finally constructed a nest sufficiently large and of sufficient strength in which to live until ready for pupation. The occurrence of this variable number of nests should be borne in mind when attempts are made to estimate the percentage of Tachinid parasitism.

Within nine or ten days the nests commence to assume definite proportions, the whole envelope being one mass of pellets of frass, which conceal the silk and help to form a stout covering. Inside this covering the larvae rest during the day, emerging to feed only at night, the needles around which the nest is constructed never being eaten.

Within six to eight days the larvae, in the plains, double their length and become a muddy green, and within 13 to 16 days after hatching they moult for the first time.

Ecdysis takes place within the nest in all the instars.

*Second Larval Instar.*—The larva at first measures in length at rest about 5.0 mm. and extended about 6.0 mm. The head is about 1.0 mm. broad. The triangular spots of the 1st instar larva have now developed into comparatively large convex plates, in colour pale cadmium-yellow, while in addition the smaller red-brown spots of the previous instar still persist, but now as definitely raised protuberances, which in the case of nos. 3, 4, 5, and 6, 7 and 8, are also pale cadmium-yellow in colour, the remainder being of a nondescript grey. Enclosed by the convex plates and the protuberances nos. 4, 5, 6, and 7, there is exhibited on the first eight abdominal segments a naked, but very darkly pigmented area, which, particularly on abdominal segments 1 and 8, is raised somewhat above the surrounding spots and protrudes posteriorly much in the form of the scutellum of the mesothorax in adult Diptera.

The convex plates of the abdominal segments and the protuberances 4, 5, 6, and 7, both of the abdominal and of the two posterior thoracic segments, bear masses of hairs that are pale cadmium-yellow in colour and in length mostly about 0.5 mm.; some, however, reach almost 1.0 mm. The protuberances 3 and 8, both on the abdominal and the three thoracic segments, also bear hairs, but of these some are pale cadmium-yellow and some pure white, the latter being rather more than 1.0 mm. in length, and the former about 0.5 mm. The protuberances 1, 2, 9, and 10 of all the segments bear hairs that are pure white in colour, and about 1.0 mm. in length.

The dorsal plate of the prothorax is considerably enlarged in this instar and bears on its anterior margin a fringe of pale cadmium-yellow hairs of 0.5 mm. in length, amongst which are set two pure white hairs of 1.0 mm. The whole fringe projects forward over the posterior portion of the head. The black head bears a few pale cadmium-yellow hairs, which project forwards. That portion of the integument which is not occupied by the plates and spots with their hairs, and by the darkly pigmented areas, is completely naked, the tergum being dark grey and the sternum flesh-coloured. There is, on each side, one light flesh-coloured stripe running



longitudinally in close proximity to the line of the spiracles, and another stripe, of much the same colour and also running longitudinally, connecting the apices of the convex plates.

The second instar larvae are considerably sturdier insects, and are capable of a much faster speed in walking. Their nests differ from those of the first instar only in being somewhat larger—about 2 inches in length by 1 inch in breadth, but varying with the number of larvae. In Plate XVI, fig. 1, two such nests can be clearly seen on the leader of the shoot. The larvae of this instar also feed only on the epidermis of the needles, but they appear not to be so concerned with the immediate necessity of obtaining food as are the first instar larvae, since they may very often be observed in the day-time engaged in what can only be described as sauntering around and about on the sunny side of the bigger branches in large patches, not in processional formation intent on some definite concern.

The larvae in the plains persist in this instar for 20–25 days, during this period migrating frequently, abandoning their old nests and constructing new ones.

*Third Larval Instar.*—The head has an average breadth of about 1.7 mm., and the larva measures in length rather less than 8.0 mm. In this instar the triangular convex plates of the 2nd instar still persist, but they are now of a colour between chrome-orange and burnt sienna; they bear on their anterior half a thick fringe of pale cadmium-yellow hairs, which in length do not exceed 2 mm., the majority being about 1 mm. The protuberances are also still much in evidence, their colour now probably being best described as reddish grey. A fringe of pale cadmium-yellow hairs, at the most 1 mm. in length, is borne on protuberances 5 and 6 of the first eight abdominal segments; nos. 5 and 6 of the two posterior thoracic segments bear a mass of such hairs; and nos. 4 and 7 of the two posterior thoracic and of the eight anterior abdominal segments bear both pale cadmium-yellow hairs of much the same length and, springing from the middle, one long white hair of rather more than 2 mm. The triangular plates of the 9th abdominal segment are pale cadmium-yellow and bear hairs of the same colour. The hypopygium bears on its margin a downy fringe of pale cadmium-yellow. The dorsum of the prothorax is now distinctly much chitinated and bears on its anterior margin pale cadmium-yellow hairs of 1 mm., which project forward over the head. The hairs of all the other protuberances are white and of varying lengths up to 2 mm.

The anterior fringe of hair on the convex plates is, in each segment, inclined forwards at an angle of about 30° from the perpendicular, and it intermeshes with the fringe springing from the protuberances 5 and 6, which is inclined backwards, also at an angle of about 30°; the darkly pigmented areas, now deep black, are thus fully exposed and are very evident. From the dark area on the 1st abdominal segment there springs a pair of tufts of feather-like scales, and on the corresponding area on the 8th abdominal segment there are two pairs of such tufts. These tufts of feather-like scales are in reality a firmly compressed, solid mass of minute hairs. It is almost undoubtedly these hairs which, on becoming detached by friction from the body of the live insect or from the cast skins, set up mechanically in the skin of man and other animals the intensely acute inflammation caused by processional caterpillars.

The remainder of the integument is, as before, naked, except that note should be taken of the fact that the hairs described above now tend somewhat to cover a larger area than hitherto, extending to the integument immediately around the plates and protuberances. The integument is light grey, but there are large areas more darkly pigmented. The two pairs of longitudinal flesh-coloured stripes, previously described in the 2nd instar, are still much in evidence. The spiracles, which for the first time are now clearly to be seen, are situated on the dorsum immediately above the lower of the longitudinal flesh-coloured stripes. In the

fully-grown 3rd instar larva, which then measures as much as 1.6 cm., there is a noticeably large expanse of naked integument between each transverse series of protuberances.

The nests of the 3rd instar larvae are markedly different from those of the two previous instars, and begin to resemble, in miniature, the typical form and colouring of the nests of the mature larvae. These third instar nests, then, may be recognised on account of their sturdy build, and the large amount of soft, white, firmly-woven silk with which they are constructed. They vary in size considerably, doubtless with the size and vigour of the colony, but normally they are about two and a half inches to three inches in length, being increased by the growing larvae, after the usual migrations, to from three to four inches. In addition, the nests of this instar have invariably as their main central support a thin apical shoot of the tree, the needles which radiate from that part of the shoot inside the nest serving only as the foundation on which the silk of the walls is woven; whereas in the previous instars the small fragile nest is often entirely supported by the needles alone.

It is noticeable that the larvae congregate in the topmost portion of the nest, and that the lower portion is empty, save for the supporting shoot with its radiating needles. The frass of the larvae drops down through this lower empty portion, the majority finding its way out through the entrance hole of the nest, which, in upright nests, is invariably located in close proximity to the supporting shoot at the extreme bottom of the nest. In nests which are constructed on shoots that are not perpendicular the entrance hole is located not in the proximity of the supporting shoot, but in the lowest side of the nest, since the entrance hole serves also as the escape hole for the frass. A typical third instar nest is shown in Plate XVI., fig. 2.

The larvae of this instar eat all portions of the green needles, thus differing from those of the previous instars, which, as has been pointed out, eat only the epidermis. The larvae in the plains persist in this instar for from about 30 to 50 days.

*Fourth Larval Instar.*—The head has an average breadth of 1.7 mm. The young larva of this instar closely resembles that of the 3rd, both in colour, appearance, and general disposition and colour of hair. There are, however, a few marked differences, as follows:—The triangular plates are now definitely burnt sienna in colour. The enclosed darkly-pigmented areas so noticeable in the previous instar are now hardly visible, not on account of any alteration in position or inclination of the hairs, which are as before, but on account of the presence on each of the seven anterior abdominal segments of a pair, and on the eighth of two pairs, of the large tufts of urticating hairs. There are now definitely two fringes of hair running transversely across the dorsum on each of the eight anterior abdominal segments, in such a manner that one fringe is anterior to, and the other posterior to, the transverse line of protuberances and triangular plates. The colour of the hair in these fringes corresponds with the colour of the hair springing from the nearest protuberance, which latter colours are the same as in the 3rd instar. The naked dorsal integument is deep black, while that of the sternum is greyish. Of the two longitudinal stripes, the lower is now white, and the upper is missing. The longest hairs now reach 4.0 mm. in length.

The nests of this instar are very typical and cannot possibly be confused with those of the previous instars. One is shown in Plate XVII., fig. 1, and on examination it will be observed that the "core" of the nest is merely a somewhat enlarged edition of a third instar nest. The filmy tracery of fine silk surrounding this core is, however, strikingly different, and, when seen in the early morning before the dew has been dispersed, or in the height of the day if the light comes from the right direction, it forces itself upon the attention, where a third instar nest would be passed unnoticed. In addition, in their continual daily entrance to and exit from the nest, the larvae form round the supporting shoot a thin, transparent, inverted cone of

fine silk, leading from the entrance hole of the nest for some inches down the shoot. In perpendicular nests the dropping frass tends to lodge in this cone and so to accentuate its visibility; it is easily discernible in the illustration. In nests that are not perpendicular the frass does not tend to lodge so easily in the cone.

The larvae of this instar at last commence seriously to attack the tree; the needles are now eaten right off as far as the sheath, and in this way whole branches are presently defoliated. The larvae still return to their communal dwelling for the day, as in previous instars, but now no further migrations are made or new nests constructed. If a hole be opened in the side or top of the nest the damage is very shortly repaired.

The length of the period for the fourth instar in the plains has not been determined with any accuracy, but it would appear to lie between 30 and 50 days.

*Fifth Larval Instar.*—The width of the head is 3.85–4.7 mm., with an average of 4.28 mm. The young larva measures 2.5–3.0 cm. in length.

The young larva of this instar is chiefly noticeable for the eight dorsal warts (the darkly-pigmented areas of the previous instars), which protrude prominently. Each of these warts is composed entirely of a mass of very fine, light yellow hairs (originally the feather-like scales of the previous instars), which are so tightly packed together that their apices present an unbroken velvety surface of a red-brown colour. Each of these masses, however, is sharply divided into four, the dividing lines, which are merely caused by the absence of hairs, crossing one another at right angles. The two anterior divisions lie flat; the two posterior, however, stand on end, so that the whole length of their anterior hairs is visible. The length of these hairs does not exceed 0.5 mm. The two fringes of hair running transversely across the eight anterior abdominal segments are now very evident as secondary hairs, being in fact considerably more numerous than, and roughly half the length of, the hairs springing from the transverse line of protuberances, which latter hairs now reach to about 5 or 6 mm. in length. These secondary hairs are a very light cream, those towards the apex of the dorsum darkening to a pale cadmium-yellow. The hairs borne by the protuberances are pure white. The integument of the dorsum is black, that of the sternum flesh-coloured, with a white line dividing these two areas. The legs are a light brown ochre, and the prolegs are slightly tinged with the same colour. The prolegs each bear 20 hooklets placed in a single line. The secondary hairs and those springing from the protuberances on the abdominal segments of the dorsum now project backwards and forwards at an angle of about 70° from the perpendicular, thus giving a curiously flat appearance to the larva and effectively exposing the warts. The main colour-scheme of this larva, when examined only with the naked eye, is black and white. The nests of half-grown larvae of the 5th instar are again fairly easily distinguishable from those of the previous instar, since all vestige of the filmy tracery has entirely disappeared, the walls of the nests now being so tightly and firmly woven as to require considerable effort to tear them, even if the attack be made upon the nest at the obviously most vulnerable point, namely, the entrance hole, by inserting a finger of each hand and pulling in opposite directions. These nests are, in addition, so firmly attached to their supporting shoot as almost to defy removal, while a large heavy nest at the apex of a rather longer and thinner shoot than usual will cause the shoot, or even the main leader sometimes, to bend right over and down, while the inverted silken cone of the previous instar now becomes a silken track and extends for some feet down the supporting branch, giving evidence of the constant passage of the larvae in search of food. On opening one of these nests large accumulations of frass, dead larvae and cast skins immediately present themselves, the living larvae being congregated together at the top, as usual.

In nests of fully-grown 5th instar larvae all evidence of any one definite entrance-hole has entirely disappeared, since what was once a reasonably small entrance-hole



on the bottom of the nest now becomes what can only be described as a large ulcer exhibiting masses of larvae, cast skins, and dropping frass, the silk from the whole bottom of the nest having been broken away by the weight of the frass; while in addition the walls of the nest are punctured in many places with holes sufficiently large to admit of the entrance and exit of the larvae. Nests containing the average number of larvae vary in size from about 6 to 8 inches long by about 4 to 6 inches at their broadest (Plates XVII, fig. 2, and XVIII, fig. 1).

Half-grown larvae of this instar anticipate the habits of the fully grown larvae by not unfrequently resting by day fully exposed on the outside of their nest. The fully grown larvae as often as not appear to make no effort whatever to return to their nest; this is more noticeable in cases where the nest is already in a state of decomposition—possibly owing to its being too small or to its having been tampered with (heavy rain noticeably affects some nests more than others)—and in cases where the colony has been forced to migrate some distance from its parent tree to new feeding grounds through the food supply having failed. In this latter case thinly made shelters are often constructed; it is, quite possibly, only these shelters which are so noticeably decomposed after heavy rain. When these temporary shelters are not constructed, the larvae remain all day singly or in small clumps scattered all over the tree; or they may congregate together in a large mass at a single point. Larvae which are resting unprotected exhibit great nervousness. The passage of some harmless insect, or of a piece of stick, within an inch or so of their position causes them to throw about violently the anterior half of their bodies, while in addition, if they are touched, they emit from their mouths a dark brown viscous fluid.

The larvae of this instar, when occurring in any number on one tree, proceed completely to strip the tree of all vestige of green, and then, if they are not prepared to pupate, they immediately migrate to another tree. As the 5th instar larva is a voracious feeder, processions at this time of year are a common sight. Lack of food is undoubtedly the direct and most obvious cause of the processions, but at the same time it should be recorded that migratory processions have occasionally been noticed from trees on which a considerable quantity of needles still remained. In procession the larvae invariably move in single file, with one leader, every succeeding larva having its head so close to the larva immediately in front as to form an unbroken chain. The writer is not of the opinion that connection is maintained by actual contact with the preceding larva, but rather by the strands of silk that are laid by each individual.

The fully grown 5th instar larva (Plate XVIII, fig. 2) measures on the average about  $1\frac{3}{4}$  inches in length. The length of the period for the 5th instar has not been determined with accuracy, but is believed to be, in the plains, from about 30 to 40 days.

*Pupal Stage.*—The average date of pupation in the plains has been found difficult to determine, but pupation undoubtedly commences some time about the middle of March and continues into April. The larvae burrow into the soil and construct separate silken cocoons. Pupation takes place normally at the foot of the host tree, at a depth of one-quarter of an inch to three inches; these depths, however, do not include the depth of the accumulated mass of dead needles which is always to be found in plantations of pine, and which in Cyprus amounts to about 2 inches. Pupation takes place in an upright position, and the pupae may be found either collected in numbers closely together within a small area of ground, or isolated and scattered. It would appear, too, that small bushes were attractive to larvae about to pupate, since many pupae are often to be found at the roots of such bushes. In addition to pupation in the ground, however, isolated cases occur of pupation in the nest, but they are rare, and the circumstances inducing such pupation must be considered abnormal. In length the cocoons average 2.2 cm., and in breadth 8.2 mm.,



the pupae being about 2 or 3 mm. shorter and about 1 mm. narrower. In colour the pupae are a dark red, and the cocoons a nondescript darkish grey.

The pupal life in the plains lasts all through the hot weather, and the adults commence emerging towards the end of the following August. These insects, however, are capable of persisting in the pupal state for 17, or even 29, months, in place of the normal five months, but the writer's experiments were on too small a scale to determine whether or not a definite percentage of pupae habitually act in this manner. Only seven such long-cycle pupae have been observed with regard to the sex, and these gave rise to six males and one female.

### Rate of Increase.

To such an extent were difficulties experienced in all attempts to induce females to oviposit in captivity and under observation that the writer is of opinion that he should disregard as worthless all results so obtained. It was found possible, however, entirely fortuitously, to arrive at very satisfactory results as regards the determination of the rate of increase, and this by a method which admits of but the minimum of error.

Firstly, the eggs and the scales from the anal tufts of 24 dead adult gravid females, with which abortive attempts had previously been made to obtain natural oviposition, were dissected and counted. The figures thus obtained are shown in Table I. It

TABLE I.

	<i>Eggs.</i>	<i>Scales.</i>
1 ... ..	224	1,000
2 ... ..	154	920
3 ... ..	150	1,072
4 ... ..	180	1,154
5 ... ..	165	1,250
6 ... ..	195	900
7 ... ..	120	768
8 ... ..	108	693
9 ... ..	132	743
10 ... ..	145	805
11 ... ..	138	781
12 ... ..	135	677
13 ... ..	156	796
14 ... ..	158	850
15 ... ..	134	927
16 ... ..	220	1,107
17 ... ..	110	780
18 ... ..	150	955
19 ... ..	155	910
20 ... ..	136	904
21 ... ..	140	873
22 ... ..	153	991
23 ... ..	86	704
24 ... ..	80	680
Totals ...	3,524	21,240
Averages ...	147	885

was very striking how closely the average number of eggs found in these females approximated to the average number of eggs in an egg-mass as recorded above (p. 165), and the writer was immediately disposed to the view that the female was

capable of laying only one mass. Secondly, this impression was subjected to trial by counting the number of scales used as the covering for the egg-mass. The result of this count, together with the corresponding number of eggs for each mass, is shown in Table II, and it becomes immediately apparent that it must, in fact, be the case that the female lays only one mass, since the small difference of 146 between

TABLE II.

		Eggs.	Scales.
1	...	241	680
2	...	198	971
3	...	152	654
4	...	128	632
5	...	158	924
6	...	200	1,036
7	...	150	780
8	...	125	642
9	...	168	760
10	...	88	610
11	...	110	446
Totals ...		1,718	8,135
Averages ...		156.2	739.6

the two average figures obtained for the scales is obviously negligible, and, for that matter, is to be expected, since the female must necessarily be provided with a few more scales than are absolutely essential.

With regard to the percentage of sexes it should be placed on record that the writer has bred through from larvae, in all, only 214 adults, of which 104 were males, 94 females, and 16 of unrecorded sex.

### **Influence of Altitude on Life-history.**

Altitude above sea level, with the attendant alterations in climatic and atmospheric conditions, exercises a very marked influence upon the life-cycle of the insect under discussion; and since the forests of Cyprus are at various elevations, an exact knowledge of the effect of altitude is obviously useful.

Since *T. wilkinsoni* is an insect that aestivates during the hot months of the year, we might expect that the greater the altitude the earlier the adults would emerge and the later the fully grown larvae would pupate, and this is in fact the case, for in the plains, that is to say at an altitude of 500 feet, the adult moth does not appear to emerge much before the end of August, whereas, on the authority of Miss D. M. A. Bate, as recorded by Mr. Tams, at the village of Platres, which she states is at 5,000-6,000 feet, but which is in reality less than 4,000 feet above sea-level, an adult was taken by her as early as 23rd July.

Again, in the plains, on 25th November 1925, it was found by the writer that by far the greatest number of larvae were still in their second instar, mostly towards the middle or end of it, that there was a fairly large number of young third instar and young second instar larvae, that some were still in the first instar, and that there were none of the fourth instar; whereas on the same date in the forest immediately above the village of Perapedhi, at an altitude of 2,600 feet, an examination of numerous nests showed that by far the greatest number contained larvae of the third instar, that a fair number had fully grown larvae of the second instar, and that a

few had larvae of the fourth. This was also the case at a point on the main road three miles below Platres, at an altitude of 2,950 feet. Immediately above Platres, however, at an altitude of 3,800 feet, different conditions were again met with, in that fourth instar larvae, which at Perapedhi were the exception and which on the plains were not to be found, were now the rule, third instar larvae being only occasionally met with, and then fully grown, and young third instar larvae and larvae of the second instar not at all. It should be remarked, in passing, that this condition was the more noticeable since the nests of the fourth instar larva are very definitely larger than those of larvae in the third instar, with the result that while nests in the plains are, at this time of year, not too easy to find unless close inspection is made of the trees, those at Perapedhi being equally difficult to detect from any distance beyond 50 paces and then only on critical search, those above Platres at an altitude of 3,800 feet already force themselves upon one's attention.

On 1st March 1926, a scrutiny was again made of nests at various altitudes, and it was found that both in the plains and up to an altitude of 3,800 feet the majority of larvae were well into the fifth instar, some even being almost fully grown, but that above 3,800 feet the majority of larvae had only just changed into the fifth instar.

On 2nd April 1926, the writer made his final examination in the differences in the dates of pupation at various altitudes, and found that in the plains it was fairly obvious that by far the greatest number of colonies had pupated, or at least were on the point of pupating, while in the hills larvae were still largely in evidence, some not even fully grown. This condition was the more easily determinable on account of the general state of the nests, which in the plains were already commencing to fall to pieces, but which in the hills exhibited all signs of being still regularly inhabited by active larvae.

### Food-plants.

The species of *Pinus* most abundant and of most importance in Cyprus are *P. halepensis*, Mill., *P. pinea*, L., and *P. laricio*, Poir., and of these *halepensis* is very noticeably the favourite food-plant. *P. pinea* is only occasionally attacked, and then apparently only as a last resort, and the writer believes that *P. laricio* is attacked even less than *pinea*. Only one other food-plant is recorded, namely *Pinus canariensis*, C. Smith, but at present this tree is of little importance in the island.

### Distribution.

*T. wilkinsoni* has been recorded only from Cyprus, but there it abounds, and it is probable that every plantation of pine throughout the island between sea-level and 4,500 feet is in some measure attacked. However, as one proceeds upwards from 4,000 feet the infestation noticeably diminishes, and at 5,000 to 5,500 feet only occasionally can a nest be found.

### Economic Importance.

The importance to Cyprus of considerably extending all that now remains of her once famous forests has long been recognised, but latterly this need has become even more urgent on account of the extensive felling carried out, of necessity, during the War and after, and also on account of a not inconsiderable number of forest fires that have lately taken place. The presence in Cyprus of this processionary caterpillar is, therefore, all the more unfortunate because it is the young, small trees which suffer most from its depredations, mature or semi-mature stands having to be attacked by a large number of larvae before exhibiting any signs of real distress.

Great damage is frequently caused by this insect in stands of young trees, for a tree of 6 to 10 feet can easily be defoliated by a single colony of healthy larvae. Complete or nearly complete defoliation is occasioned year after year to innumerable trees all over the island, and, although doubtless the majority of such trees make an apparently good recovery, such treatment can have in the long run but one effect. In addition, should defoliation occur late in the season, that is to say in late March or early April, and should it so chance that the season is an early one, no abundant recuperative rains falling in or after April, as is often the case, it frequently happens that the attacked trees die during the heat of the summer. And another source of danger is the inexperienced or slovenly woodsman, who, in removing from the trees what nests are within his reach, either through ignorance or indolence unnecessarily damages the branches.

On mature or semi-mature trees this insect is, in the opinion of the writer, at present of little significance, nor is it of much significance on stands of *Pinus pinea* or *P. laricio*, except as a source of infestation. Larger trees attacked by numerous colonies probably owe their powers of resistance to their greater and deeper root-system, while it is quite possible that *P. pinea* is more generally resistant through its habit of growing successfully only in sites plentifully supplied with water, or at least in deeper soil than *P. halepensis*, which latter is notoriously more addicted (and to its undoing in Cyprus) to stony ground.

### Natural Enemies.

Unfortunately little work has been accomplished in the question of checks, beyond the determination merely of the broad outlines of the life-histories of the more important parasites; the results obtained from this work, however, have been so encouraging as to convince the writer that the clue to the ultimate complete control of this processionary is to be found in further study of the somewhat intricate life-cycles of, particularly, the Chalcid and Tachinid parasites of this pest. The following section of this paper will, therefore, do little more than set forth what meagre information has been collected, and indicate for subsequent workers the most profitable lines of study.

#### *Parasites of the Egg.*

##### 1. *Ooencyrtus pityocampae*, Mercet.

Although many examples of this Encyrtid were bred, exact information regarding dates of emergence was recorded only from two breeding-cages, and this is presented in Table III. There were in these cages egg-masses that had been collected in the field, primarily with the object of determining the incubation period. On the discovery that they were parasitised it was at once decided to remove from the cage all adult parasites immediately on emergence in the endeavour to obtain some idea as to the larval period of the parasite. This was carefully and apparently thoroughly done, but on the occurrence of a second brood in May doubts were at once engendered. The occurrence of this second brood or, if it was not a true second brood, this delayed emergence is in the opinion of the writer of importance, for, taking into consideration the life-history of *T. wilkinsoni* and the fact that no further emergence of Chalcids from these eggs took place after May, it becomes apparent that there is an alternative host, though endeavours to discover it have been in vain.

##### 2. *Anastatus bifasciatus*, Fonscolombe.

A few individuals of this Eupelmid have also been bred from egg-masses of *T. wilkinsoni*, from which *Ooencyrtus pityocampae* were also emerging. At the present date, however (1926), it appears to be of very minor significance. These parasites also seem to be double-brooded, adults having emerged in May from egg-masses collected in October. It might be suggested that they are hyperparasites on *O. pityocampae*.



TABLE III.

Number of egg-masses of <i>T. wilkinsoni</i> ...	12	8
Total number of eggs	1,353	1,328
Date of collection ...	28.ix.1924	14.x.1924
Emergence of <i>O. pityocampae</i> .	—	—
October 1924.		
2nd ... ..	9	—
3rd ... ..	4	—
4th ... ..	1	—
6th ... ..	6	—
7th ... ..	8	—
8th ... ..	3	—
9th ... ..	1	—
10th ... ..	1	—
11th ... ..	2	—
12th ... ..	3	—
13th ... ..	2	—
14th ... ..	1	—
15th ... ..	1	5
16th ... ..	2	3
17th ... ..	—	1
18th ... ..	7	2
20th ... ..	4	3
21st ... ..	—	3
22nd ... ..	4	1
23rd ... ..	—	4
24th ... ..	1	—
25th ... ..	2	3
26th ... ..	3	—
27th ... ..	3	—
28th ... ..	1	3
29th ... ..	—	1
31st ... ..	—	1
November 1924.		
2nd ... ..	—	1
3rd ... ..	—	1
May 1925.		
5th ... ..	5	—
6th ... ..	15	156
7th ... ..	—	14
11th ... ..	—	24
? ... ..	3	10
Totals ... ..	92	236
Parasitism per cent. ... ..	6.8	17.8

*Larval Parasites.*1. *Erigorgus melanobatus*, Grav.

During the months of February, March and April, adults of both sexes of this Ichneumonid may be observed on and around the nests of the processionary, and the females can be watched ovipositing on such larvae as are unprotected by silk; they may sometimes also be observed entering the nests for the purpose of oviposition

on larvae at rest inside, and this habit has been found to be very usual. Aestivation occurs inside the cocoon of the host, the host apparently being not sufficiently injured by the parasitic larva to prevent normal preparations for pupation. In the following spring the parasite emerges from its host's cocoon in the ground.

2. *Compsilura concinnata*, Mg.
3. *Tricholyga segregata*, Rond.
4. *Ceratochaeta caudata*, Rond.

That these three Tachinid flies are checks of considerable importance is shown in Table IV. Unfortunately, at the time that the breeding experiments on these flies were carried out, it was found impossible to differentiate between the three species, not only with regard to the percentage of parasitism, but also with regard to the dates of emergence of the adults. It can be stated, however, that Tachinid parasites emerged on 25th October, on 9th and 10th November, and on 10th December, in a cage that had contained larvae which in the middle of the previous March were being attacked by a Tachinid fly. The date of first emergence, and consequently the date on which *T. wilkinsoni* larvae are normally first attacked in the beginning of the season, may not be accurately known, but on the other hand numerous Tachinids have been bred from larvae collected at Perapedhi on 12th December, and in addition it has been definitely established that pupation of these parasites, which takes place inside the nests, certainly commences as early as the beginning of March, and possibly even earlier, parasitic pupae having been found on 1st March in nests occurring both in the plains and in the hills.

At least one of these three species is double-brooded, for emergence of Tachinids from nests collected on 12th December is recorded as having taken place in the middle of March; and throughout March adult Tachinids may be observed on or in *Thaumetopoea* nests.

In April 1924, 20 *T. wilkinsoni* nests were collected at Perapedhi for the purpose of determining the numbers of Tachinid pupae in them, and 12 nests were also collected from along the Limassol-Paphos road, at an altitude of about 150 feet, and the results of this count are shown in Table IV. It will be observed that the average is five parasitic pupae for each nest, or supposing that 150 is the average number of larvae in a nest, a parasitism of 3·4 per cent. Actually the percentage must be considerably higher, for, as we have already pointed out, larvae of the 5th instar frequently abandon their nests in search of a more ample supply of food.

TABLE IV.

Number of <i>T. wilkinsoni</i> nests.	Number of Tachinid puparia in each.	Total number of Tachinid puparia.
6	0	0
7	1	7
2	2	4
3	3	9
4	4	16
1	6	6
1	8	8
3	9	27
1	10	10
1	11	11
1	16	16
1	19	19
1	32	32
Totals 32	—	165

Unfortunately the pupae of these Tachinids are themselves very highly parasitised by a Pteromalid, *Dibrachys boucheanus*, Ratz., and not one single adult Tachinid emerged from the 165 puparia taken from the nests. Admittedly, the conditions were abnormal, for the fly puparia were kept together in two cages, loose and entirely exposed, and a single batch of hyperparasites from one parasitised puparium in each cage would doubtless have been sufficient to parasitise all the remaining puparia. In all, 1,077 hyperparasites emerged from these 165 puparia; but there can be no doubt that in the field, where the conditions are altogether different, *Dibrachys*, although a factor to be considered, cannot possibly occasion such a high percentage of hyperparasitism as that noted above.

*Dibrachys boucheanus* has been taken in Cyprus in enormous numbers in grain stores in certain parts of the island. The following insects appear normally to occur in most grain stores in Cyprus:—

*Tenebroides mauritanicus*, L., *Tribolium castaneum*, Hbst., *Calandra granaria*, L. *Calandra oryzae*, L., *Trogoderma versicolor*, Creutz., and an unidentified Lepidopteron.

### *Pupal Parasites.*

No pupal parasites have been observed.

### *Predators.*

#### 1. *Monomorium gracillimum*, Sm.

This ant has been found in two successive years completely eating out egg-masses of the processionary only on one particular tree in the plantations of the Government Farm at Athalassa. In no other locality has this ant been observed, and nothing further is known of its occurrence or distribution in Cyprus.

#### 2. *Tapinoma erratica*, Latr.

This ant may be constantly observed in and around nests of the processionary. It functions chiefly as a scavenger, removing to its own nest all the cast skins and dead larvae. It has occasionally been observed attacking living larvae, but it must be admitted that these were always very unhealthy and appeared already to be on the point of death. It seems therefore very doubtful whether this ant exercises any real check upon the moth, and it is even possible that the reverse may be the case, for those larvae which are more readily attacked are sluggish and weakly, and are probably parasitised. This ant is common in the plains, nesting on the ground round low-lying tufted plants.

#### 3. Birds.

The writer believes that only on one occasion have birds been definitely observed and authentically reported as attacking this species of processionary. The birds concerned were a species of tit.

### **Control Measures.**

Until 1923, that is to say until the writer's arrival in Cyprus, the measure employed by the Forest Department in attempts to control this moth was solely the destruction of nests and larvae, and that only at the time of year when they were most easily to be found, namely, in February and March, and when the larvae were most highly parasitised. That this measure, when utilised within a small definite area, produces some results is not to be denied, but that it is of value when attempted over a large tract of forest, or in widely scattered and isolated plantations, is extremely doubtful; and since it is these larger areas and the smaller, scattered,

self-sown plantations that so urgently require protection, we can pass over the hand-picking method, as such, noting, however, that, in the following recommendations, hand-picking, when used in conjunction with the encouragement of existing parasites, will figure very largely.

In the writer's opinion there is no doubt that any serious attempt in the encouragement of larval parasites will produce far-reaching results. It has been shown that, even under the present conditions, the Tachinids sometimes occasion a parasitism as high as 20 per cent., and although the value of the Ichneumonid has yet to be determined, it is patent that almost any measure would be of use in assisting this insect, which emerges so late in the season as compared with its host. As regards the existing egg-parasites it would seem to be impossible to devise any method of encouragement; the decreasing occurrence of the pest, through increased larval and pupal parasitism, would, however, have a considerable effect upon the number of egg-masses available for parasitism, and hence also upon the percentage of egg-parasitism.

The following, therefore, are the measures that the writer advocates in the encouragement of the larval and pupal parasites:—

#### *Method A.*

(1) Firstly, there should be constructed on the ground, in the open, preferably round a small group of large, unhealthy, malformed or dying trees, or other trees the destruction of which is not objected to, a continuous trough at least 4 inches broad at the top, of metal, concrete, or other material suitable for the retention of water. Water, with possibly a little paraffin, should be poured into this trough, thus making an isolated area out of which processionary larvae would be unable to escape. The number of such isolation areas that should be constructed will naturally depend upon the funds available, not only for their initial erection, but also for their upkeep, but the construction of at least one within every definite area of forest should be attempted. The initial cost should be small; incidentally it will probably be found that the greatest expenditure will be occasioned by the continual transport of the requisite amount of water, and in this connection it may be suggested that possibly the utilisation of waste engine oil, large quantities of which can easily be obtained in Nicosia, might be found less expensive in the long run.

(2) From December or January onwards, or earlier in the hills, large quantities of the more easily accessible nests of the processionary should be collected and placed within the nearest isolation area. It is recommended that they be not thrown on the ground but attached in as natural a manner as possible to the branches of the trees within the area. It will be observed now that the trees selected for isolation must necessarily provide a considerable quantity of needles if they are satisfactorily to maintain through to maturity so many larvae, and possibly it would be wise to select trees of the species *P. pinea*, not only in that this variety bears needles in greater quantity than *P. halepensis*, but also because it is more resistant to the attacks of *T. wilkinsoni* larvae. All the nests so collected should be left absolutely untouched (except that they may be advantageously dealt with in the manner recommended in Method B, below), and the larvae should be allowed to pupate normally inside the isolation areas.

(3) Some little while before the emergence of the adult moths the whole ground within the isolation area should be covered with some such material as old tent-canvas; that is to say, with a material sufficiently strong and devoid of holes to ensure that all emerging moths are prevented from escaping. Whatever the material that is used it should be firmly fastened to the ground and its condition constantly inspected. It should remain in position until such a date when it can be confidently



asserted that all the moths have emerged and died. It should then be removed to allow the escape of the Ichneumonid parasites.

It will be observed that little more labour is involved by this method than by the old method of control, namely, the collection and destruction of nests, and yet it will be just as effective in preventing the emergence of the moths, while, in addition, all the parasites, both the Ichneumonids from the ground and the Tachinids from the nests, will succeed in emerging, whereas under the old method the parasites were killed at the same time as their hosts. Thus, if this measure is persistently carried out, the incidence of parasitism will steadily increase.

#### *Method B.*

On the pupation of the processionary larvae it is not desirable that the collection of their nests should cease, for the Tachinid parasites pupate within the nests, which during the summer and autumn are sufficiently disintegrated by the weather to cause the parasitic puparia to fall to the ground, where large numbers must be destroyed by predatory insects such as ants. It is strongly recommended that the collection of disintegrating nests be assiduously carried out, the nests so collected being stored in rows, hanging, at the same angle as they hung on the trees, from a series of horizontal and parallel cross-pieces, erected in the open, but protected from sun and rain by light roofing, and from ants by the immersion of the supporting uprights in concrete beds so shaped as to hold, and maintain round the foot of the uprights, a pool of water or oil. These shelters should not be costly, four uprights in concrete blocks, with a light thatching of palm leaves over wire-netting, would appear to meet the case.

In addition to the encouragement of the larval and pupal parasites already existing in Cyprus, it is strongly recommended that attempts be made to introduce such parasites and predators of other species of processionary caterpillars as do not already exist in the island; and in this connection it is suggested that probably *Tetrastichus vinulæ* and *Trichogramma semblidis*, two of the egg-parasites of *Thaumetopoea pityocampa*, are the insects that would best repay the trouble and expense of introduction.

In the considered opinion of the writer, the Cyprus processionary moth can be controlled by the utilisation of the measures outlined above.

#### **Summary.**

*Thaumetopoea wilkinsoni*, Tams, is known only in Cyprus, where it abounds, attacking all species of pine, but chiefly *Pinus halepensis*, Mill.

In the plains the adults emerge from the end of August to the beginning of October. The eggs are laid, shortly after emergence, in cylindrical masses round pine needles, the masses averaging 150 eggs. Only one mass is laid by each female. The incubation period is about 45 days.

The five larval instars are described, as well as the differences in the habits and nests in the various instars. The length of the larval life varies from 116 to 173 days. Only in the fourth do larvae remain in the same nest throughout the instar, as they frequently migrate, moving in single file to new feeding grounds, and there construct a new nest. Six such migrations have been observed for one colony during its three earlier instars.

Pupation, which commences in the plains about the middle of March, takes place in the ground in silken cocoons at a depth of  $\frac{1}{4}$  to 3 inches, the pupal life lasting all through the hot weather.

Altitude considerably influences the life-history—the greater the altitude the earlier the emergence of the adult and the later the pupation of the fully-grown larvae, with consequent alterations in the length of the larval periods.

Of the checks, two species of Chalcid egg-parasites have been shown to occasion a parasitism of over 17 per cent., and three species of Tachinid larval parasites sometimes to occasion a parasitism of at least 30 per cent. There is also an Ichneumonid larval parasite. This latter aestivates in the pupa of its host; the Tachinids leave their larval hosts and pupate in the nest of the processionary.

Re-afforestation in Cyprus, both natural and artificial, being an urgent necessity, this processionary is of great economic importance, as stands of young trees suffer very heavily from its attacks, one colony of larvae being sufficient to strip and, if the late rains fail, to kill a small tree. The writer considers, however, that control is possible by encouraging the parasites and predators, methods for which are outlined.

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#### APPENDIX.

##### Meteorological Conditions in Cyprus.

##### Rainfall in 1924 (in inches).

	Nicosia.			Limassol.
	Total.	Max.	Date.	Total.
January ... ..	5.69	2.69	7th	7.16
February ... ..	1.45	0.46	13th	3.12
March ... ..	0.92	0.33	1st	0.56
April ... ..	Drops	Drops	14th	0.00
May ... ..	2.72	1.78	19th	0.41
June ... ..	0.41	0.36	5th	0.04
July ... ..	0.02	0.02	10th	0.00
August ... ..	0.00	0.00	—	0.00
September ... ..	0.91	0.88	23rd	Drops
October ... ..	2.23	0.78	28th	2.63
November ... ..	2.02	0.49	2nd	4.11
December ... ..	3.50	0.89	18th	2.49
Year ... ..	19.87	—	—	20.52

*Rainfall in 1925 (in inches) for places in the hills. Troodos Range.*

	Altitude in feet.	1st Jan. to 31st Mar.	1st Apr. to 30th Sept.	1st Oct. to 31st Dec.	Total.
Kykkou Monastery ...	3,500	7.55	3.90	8.10	19.55
Ay. Nikolaos ...	3,000	7.84	3.76	7.69	19.29
Kilani ...	2,700	10.80	5.50	11.36	27.66
Stavros Psokas ...	2,500	9.19	4.29	8.87	22.35
Pano Panayia ...	2,500	6.79	3.23	7.52	17.54
Evrykhon ...	1,400	5.79	2.45	4.28	12.52
Cp. for same year:—					
Nicosia ...	536	1.99	1.26	3.91	7.16
Limassol ...	53	8.17	1.23	4.80	14.20

NOTE.—Considerable differences in the returns for the various years are noticeable in that the heavy rains may in one district occur after or before January 1st, thus giving a totally wrong impression in some instances; thus, the total rainfall in Nicosia during 1925 was only 7.16 inches, as against 19.87 for 1924, the heavy rains for the season 1925–26 falling after 1st January 1926, and for the season 1924–25 before 1st January 1925.

*Air Temperature and Relative Humidity, Nicosia P.W.D. Observatory.  
Year 1924. Alt. 522 ft.*

	Air Temperature (Fahr.).							Relative Humidity per cent.	
	8 a.m.	3 p.m.	Mean.	Absolute Min. and Max.				8 a.m.	3 p.m.
				Min.	Date.	Max.	Date.		
January ...	48.2	54.8	50.2	34.0	29th	64.0	3/5	89	83
February ...	51.1	58.5	51.8	34.0	1st	69.0	15th	81	74
March ...	56.4	64.1	55.8	35.0	16th	78.0	23th	74	69
April ...	66.3	75.2	64.2	44.0	5/8	86.0	26th	63	50
May ...	72.4	78.2	70.2	51.0	4/5	90.0	16th	64	56
June ...	79.7	87.6	78.4	61.0	2/19	100.0	30th	64	55
July ...	85.1	94.7	83.6	63.0	29th	102.0	20/21	58	65
August ...	84.2	93.8	83.3	62.0	9th	107.0	24/25	64	69
September ...	80.9	90.7	79.9	62.0	28th	102.0	13th	66	57
October ...	70.6	77.5	70.2	50.0	28th	92.0	5/6	73	59
November ...	60.1	67.6	61.0	44.0	25/27	82.0	5th	81	71
December ...	50.5	57.2	51.2	30.0	28th	68.0	5/9	81	71
Year ...	67.1	75.0	66.6	—	—	—	—	72	—

NOTE.—The mean temperature as recorded in the screen at Nicosia during 1924 was 66.6° F., as against 65.8° F. for the last 15 years. The mean maximum was 77.8° F., the mean minimum 55.4° F. as against 77.5° F. and 54.2° F. respectively for the last 15 years.

The rainy and cool season is from October to March. The climate is varied, but dry in the plains in summer; damp on the seashore and cool on the hills.

The above data and summary have been abstracted from the Blue Book published by the Cyprus Government.





Fig. 1. Nests of 2nd instar larvæ of *Thaumetopoea wilkinsoni*, Tams.

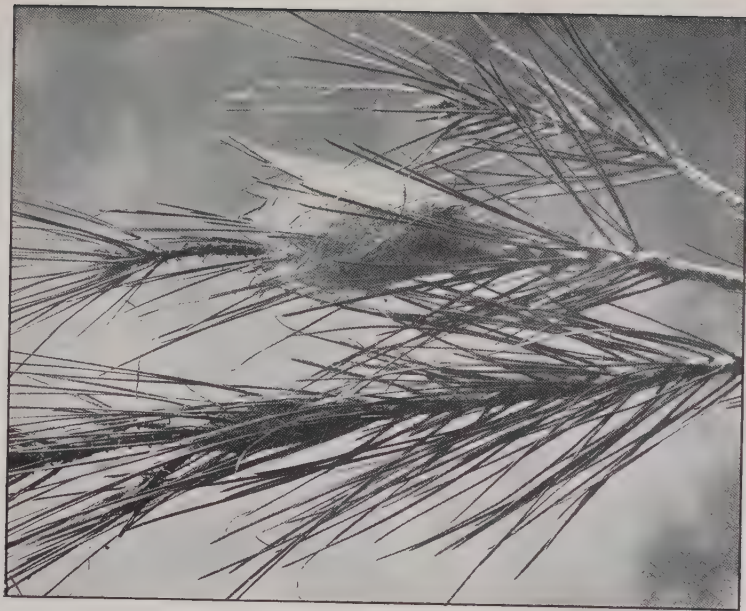


Fig. 2. Nest of 3rd instar larvæ.







Fig. 1. Nest of 4th instar larvæ.

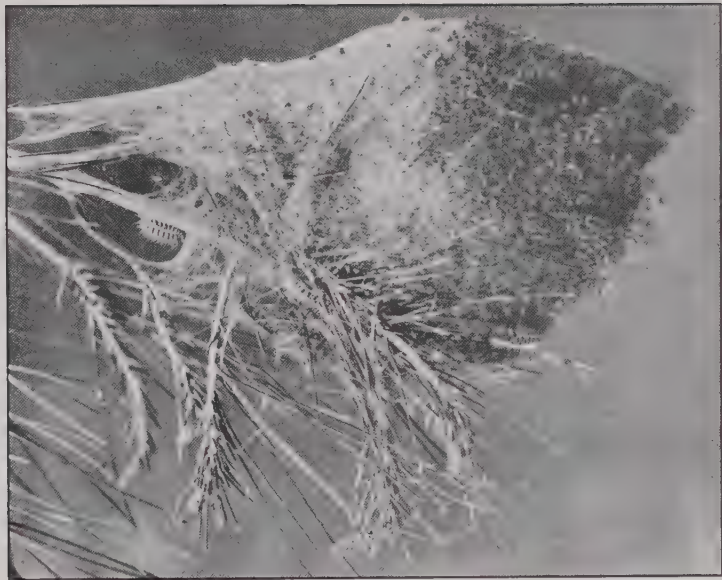


Fig. 2. Nest of 5th instar larvæ.





Fig. 1. Another nest of 5th instar larvæ.



Fig. 2. Adult larva.

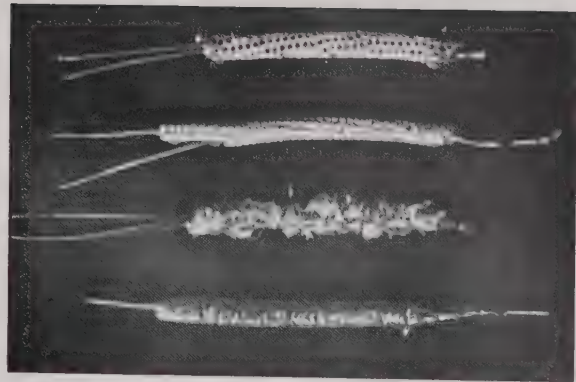


Fig. 3. Egg mass (a) as laid by female;  
 (b) after escape of young larvæ;  
 (c) with scales stripped to show eggs;  
 (d) with scales stripped, after emergence  
 of larvæ.





## MOSQUITOS BRED FROM DRY MATERIAL TAKEN FROM HOLES IN TREES.\*

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*West African Yellow Fever Commission, Lagos, Nigeria.*

An investigation of the breeding habits of the yellow fever mosquito, *Aedes aegypti*, Linn., in West Africa was begun in December 1925. This was undertaken for the purpose of ascertaining if the selection of breeding-places of this mosquito in Africa differs from that in the Western Hemisphere, and, if so, to learn if this difference is sufficient to be of material importance in yellow fever control work.

Since it was believed that breeding in tree-holes constituted a problem worthy of investigation, it was decided to make a survey of the rot-holes and fork-hollows in trees in the vicinity of Lagos, in the Southern Province of Nigeria. This survey was begun on 8th December 1925, shortly after the rainy season had passed and the dry season had set in. However, after inspecting a number of trees, the fact became evident that this was not a propitious time of the year for finding larvae in such places, since practically all of the holes were without water, and their contents, consisting of leaves and débris, were dry.

This early drying of the material in the holes drew my attention to the probability of mosquito eggs remaining in the holes, surviving the drought of the dry season and producing larvae with the beginning of the rains. In furtherance of this question, an examination of the dry holes was then began, and material collected from all those that were suitable. The term "suitable" in this sense signifies that the hole was in a living tree—of a formation to contain water, for a short time at least—that the aperture was of sufficient size to allow the débris to be removed and the inside of the hole scraped, and that the contents were dry. The distance of the trees from habitations, their location in open areas or thick bush, the height of the holes from the ground, the exposure of the holes to the sun, or the amount of débris contained caused no discrimination to be made.

This survey was carried on until material was obtained from 100 trees with a total of 114 holes. In several instances two or more suitable holes were found in a tree. No collections were made from holes in which the contents were perceptibly moist.

The trees included in this survey were mostly situated in the Ikoyi and Yaba districts. Ikoyi, which is a suburb of Lagos, is a nearly flat area, with light sandy soil, and a few low-lying swampy places along the edge of the lagoon. Many residences occupied by Europeans are present here, and this area bids fair to become, some day, the principal European residential section of Lagos. Samples of material were collected from 72 holes and hollows in 65 trees in this district. The majority of the trees occurred in an area approximately one mile long and 250 yards wide, which extends along the north side of the Ikoyi Road, between the cemetery and a point east of Cameron Road. Thirty-one of these samples were taken from 29 cashew trees (*Anacardium occidentale*), and 41 from 36 trees of another variety, the identification of which has not yet been learned.

In the Yaba district, which is about four miles from Lagos, 24 samples were obtained from 22 trees. These trees consisted of mango (*Mangifera indica*), 13; breadfruit (*Artocarpus incisa*), 3; banyan (*Ficus* sp.), 3; bitter kola (*Garcinia conrauwana*), 1; and two unidentified species. Thirteen trees in two small native villages, Igbube and Ojuelegba, near Yaba, yielded 18 samples. These trees were, breadfruit 6, unidentified variety 5, banyan 1, and mango 1.

\* The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Board.

Notes were kept on the amount and nature of the material and the fauna present in each hole in an endeavour to discover any conditions that might serve as either an attraction or repellent to the mosquito when in search of a place of oviposition.

The material found in the holes varied considerably. A large percentage contained leaves, either whole or in fragments, in addition to other débris. Some were partly filled with humus, mixed with droppings from lizards, birds, etc., and various kinds of nuts and seeds. Others only contained pieces of decayed wood as light and dry as tinder. A few were nearly filled with ant nests, some empty and others inhabited, and nothing but sand was noted in several.

The fauna observed included lizards, centipedes, millepedes, cockroaches, beetles, ants and various other insects. Ants were present in about 85 per cent. of the holes. Only a few were found in some, while others contained thousands.

A large iron spoon with a handle about ten inches long was used for collecting the débris and for scraping the inside of the holes. This scraping of the sides and bottom of each hole was done quite thoroughly to remove as much of the decayed lining as possible, and probably resulted in securing many more eggs than if the loose material only had been taken. All the contents, leaves, débris and scrapings of each hole were collected and recorded as one sample.

Cigarette tins about three inches deep and two and a half inches in diameter, with a capacity of 270 cc., were used as containers and for roughly measuring the contents of each hole. The amount of the samples varied from one-fifth of a tin to three tins full.

When brought to the laboratory each sample was placed in a glass dish (moist chamber) eight and a half inches in diameter and three inches deep. A small amount of water was then poured into the dish, this being only enough to float the major portion of the material clear of the bottom of the dish for a few hours until it gradually became water-soaked and sank. The dish was then covered and left until the following day, when a few bread crumbs were dropped in, and more water added until it was about two-thirds full. After four days the contents of the dish were carefully examined, and all larvae present were transferred to small breeding jars for pupation and emergence of the imagines.

Mosquitos were bred from 40 of the samples, taken from 38 trees, which gave a positive index of 38 per cent. for the trees and 35 $\frac{2}{3}$  per cent. for the holes. Two trees each contained two positive samples. Eight species were represented in the results from the 40 positive samples. These, with the number of holes in which each occurred, either alone or associated with other species, are given in Table I.

TABLE I.  
*Species of Mosquitos and Number of Holes in which each occurred.*

Species.	Number of holes.
<i>Aedes (Stegomyia) luteocephala</i> , Newst. ...	27
<i>Aedes (Finlaya) wellmani</i> , Theo. ...	14
<i>Aedes (Stegomyia) africanus</i> , Theo. ...	11
<i>Aedes (Aedimorphus) apicoannulatus</i> , Edw. ...	8
<i>Aedes (Stegomyia) apicoargentea</i> , Theo. ...	6
<i>Aedes (Stegomyia) aegypti</i> , Linn. ...	3
<i>Aedes (Stegomyia) simpsoni</i> , Theo. ...	3
<i>Aedes (Finlaya) longipalpis</i> , Grünb. ...	2

One of the three samples from which the yellow fever mosquito, *Aedes aegypti*, was bred was taken from tree no. 25 at Ikoyi. This tree stood approximately 125 yards

from the nearest habitation. The other two were from trees located in compounds at Yaba, neither of these was more than ten yards from houses occupied by natives.

The samples taken from trees at Yaba (Igbube and Ojuelegba included) seemed to produce more fruitful results, as regards a higher percentage of positive findings and a larger variety of species, than those taken from an equal number of trees at Ikoyi. The results obtained at each place are shown in Table II.

TABLE II.

*Species of Mosquitos and Number of Tree-holes in which each occurred at Yaba and Ikoyi.*

Species.	Tree-holes at Ikoyi (72 samples— 20 positive).	Tree-holes at Yaba (42 samples— 20 positive).
<i>A. luteocephala</i> ... ..	16	11
<i>A. wellmani</i> ... ..	5	9
<i>A. africanus</i> ... ..	9	2
<i>A. apicoannulatus</i> ... ..	—	8
<i>A. apicoargentea</i> ... ..	—	6
<i>A. aegypti</i> ... ..	1	2
<i>A. simpsoni</i> ... ..	—	3
<i>A. longipalpis</i> ... ..	—	2
Totals ... ..	31	43

Nothing definite was noted to indicate that the different species prefer certain varieties of trees for places of oviposition. It is possible that such a preference occurs, but, if so, a much larger series of trees would have to be investigated, and all factors in connection with their location, proximity to habitations and varieties of neighbouring trees would need to be closely considered before it could be established.

One would expect that some of the fauna, especially the omnivorous ants, that inhabit the holes during the dry season would devour all the mosquito eggs present. It is probable that large numbers are destroyed in this way, but it is also quite certain that many are not. Sample no. 76, from which 34 *A. wellmani* and 11 *A. luteocephala* were bred out, was taken from a hole in which thousands of ants were present. This was but one of a number of instances where positive samples were obtained from holes occupied by large numbers of ants.

As previously mentioned, there were practically no tree-holes in which water was present at the time this survey was begun, and no rain occurred during the period that it was carried on until 6th February 1926, the day on which the last material was collected. Rain to the amount of over one inch fell on that date.

All samples were collected by me, or in my presence, and a careful system of numbering was used to prevent mistakes.

The number of each positive hole and tree, dates on which samples were collected, location and varieties of trees, and species of mosquitos that were bred from each sample are shown in Table III.

#### Conclusions.

The foregoing observations demonstrate that the eggs of eight species of mosquitos, *Aedes luteocephala*, *A. wellmani*, *A. africanus*, *A. apicoannulatus*, *A. apicoargentea*, *A. aegypti*, *A. simpsoni* and *A. longipalpis*, are resistant to the drought of the dry season, and remain viable until the beginning of the rains.



TABLE III.

Data from Samples from which Positive Results were obtained.

Sample collected.	Number of tree.	Number of hole.	Situation of tree.	Species of tree.	Species of Mosquitos bred out.					
					1*.	2.	3.	4.	5.	6.
1925.										
Dec. 8 ...	1	1	Ikoyi	Cashew	<i>A. lutocephala</i>					
Dec. 8 ...	3	3	Ikoyi	Cashew	<i>A. lutocephala</i>					
Dec. 22 ...	5	5-A	Ighube	Banyan	<i>A. wellmani</i>					
Dec. 23 ...	8	8	Ikoyi	Cashew	<i>A. lutocephala</i>					
Dec. 24 ...	16	16	Ikoyi	Cashew	<i>A. lutocephala</i>					
1926.										
Jan. 6 ...	24	24	Ikoyi	Cashew	<i>A. lutocephala</i>					
Jan. 6 ...	25	25	Ikoyi	Cashew	<i>A. lutocephala</i>	<i>A. aegypti</i>				
Jan. 6 ...	26	26	Ikoyi	Cashew	<i>A. lutocephala</i>					
Jan. 8 ...	27	27	Ikoyi	Cashew	<i>A. africanus</i>	<i>A. lutocephala</i>				
Jan. 12 ...	34	34-A	Ikoyi	?	<i>A. wellmani</i>	<i>A. lutocephala</i>				
Jan. 12 ...	36	36	Ikoyi	?	<i>A. wellmani</i>					
Jan. 12 ...	37	37	Ikoyi	Cashew	<i>A. lutocephala</i>					
Jan. 12 ...	39	39	Ikoyi	?	<i>A. africanus</i>	<i>A. lutocephala</i>				
Jan. 19 ...	42	42	Ikoyi	?	<i>A. africanus</i>					
Jan. 19 ...	44	44	Ikoyi	?	<i>A. africanus</i>	<i>A. lutocephala</i>				
Jan. 19 ...	45	45	Ikoyi	?	<i>A. wellmani</i>					
Jan. 19 ...	46	46-A	Ikoyi	?	<i>A. lutocephala</i>	<i>A. africanus</i>				
Jan. 19 ...	46	46-B	Ikoyi	?	<i>A. lutocephala</i>	<i>A. africanus</i>	<i>A. wellmani</i>			
Jan. 19 ...	47	47	Ikoyi	?	<i>A. lutocephala</i>	<i>A. africanus</i>				

Jan. 22 ...	55	Ikoyi	?	<i>A. africanus</i>				
Jan. 29 ...	72	Yaba	Mango	<i>A. luteocephala</i>	<i>A. apicoargentea</i>	<i>A. wellmani</i>		
Jan. 29 ...	75	Yaba	?	<i>A. luteocephala</i>	<i>A. wellmani</i>			
Jan. 29 ...	76	Yaba	?	<i>A. wellmani</i>	<i>A. luteocephala</i>			
Jan. 29 ...	76-B	Yaba	?	<i>A. africanus</i>	<i>A. wellmani</i>			
Jan. 29 ...	77	Yaba	?	<i>A. luteocephala</i>				
Feb. 1 ...	82	Igbube	?	<i>A. simpsoni</i>	<i>A. wellmani</i>			
Feb. 1 ...	83	Igbube	?	<i>A. apicoargentea</i>	<i>A. apicoannulatus</i>			
Feb. 3 ...	84	Yaba	Breadfruit	<i>A. apicoargentea</i>				
Feb. 3 ...	85-A	Yaba	Breadfruit	<i>A. luteocephala</i>	<i>A. apicoannulatus</i>	<i>A. simpsoni</i>	<i>A. apicoargentea</i>	
Feb. 3 ...	87	Ojuelegba	Breadfruit	<i>A. apicoannulatus</i>	<i>A. aegypti</i>	<i>A. longipalpis</i>		
Feb. 3 ...	88	Ojuelegba	Breadfruit	<i>A. apicoannulatus</i>				
Feb. 4 ...	89	Yaba	Mango	<i>A. luteocephala</i>	<i>A. apicoannulatus</i>			
Feb. 4 ...	90	Yaba	Mango	<i>A. wellmani</i>	<i>A. apicoannulatus</i>			
Feb. 4 ...	92	Yaba	Mango	<i>A. apicoannulatus</i>	<i>A. luteocephala</i>	<i>A. simpsoni</i>	<i>A. africanus</i>	<i>A. longipalpis</i>
Feb. 4 ...	93	Yaba	Mango	<i>A. luteocephala</i>				
Feb. 4 ...	94	Yaba	Mango	<i>A. luteocephala</i>	<i>A. apicoargentea</i>			
Feb. 6 ...	98	Yaba	Breadfruit	<i>A. apicoargentea</i>	<i>A. apicoannulatus</i>	<i>A. aegypti</i>	<i>A. luteocephala</i>	
Feb. 6 ...	99	Yaba	Mango	<i>A. luteocephala</i>				
Feb. 6 ...	100	Yaba	Mango	<i>A. wellmani</i>				

\* The species are shown in the columns in the order of predominance in which they occurred, *i. e.*, the adults of the species in Column 1 exceeded those in Column 2.



## SECOND NOTE ON THE COCCIDAE OF PALESTINE.

By Dr. F. S. BODENHEIMER,

*Entomologist, Pal. Zion. Ex. Agric. Exper. Stat., Tel Aviv (Palestine).*

The following lines may be regarded as a first additional note to a former paper of the author's (Zion. Organ. Agr. Expt. Sta., Bull. 1, July 1924). It contains 14 species not recorded in the first list, two of which are new to science. The numeration follows that of the former paper. I wish to tender my acknowledgements to Mr. W. J. Hall, Cairo, for determining some species of DIASPINAE and to Mr. H. Aron for preparing the illustrations.

66. *Aonidia lauri* (Bché.) has been taken once from the smaller branches of *Laurus nobilis* at Mikweh Israel, 23rd September.

67. *Aspidiotus nitrariae*, March. This species, known up till now only from Tunis, has been found once on *Nitraria tridentata* in the Jordan Valley, in a wadi near Jisr-el-Ghoraniyeh, 18.iv.1925. The insects produce and reside in a small cavity on the leaves, mostly on the upper surface, opposite which the leaves are pouches.

68. *Aulacaspis rosae* (Bché.). Erroneously recorded in the earlier paper as *Aulacaspis pentagona*, Targ., which has not yet been discovered in Palestine. *A. rosae* is not uncommon on the stems of *Rubus discolor* on the shores of the Lake of Tiberias, between Dagania (23rd Sept.) and Kinereth (25th June).

69. *Lepidosaphes intermittens*, Hall. This species was found only once, at Kinereth on the shores of the Lake of Tiberias, 14.xii.1925. The scales covered almost entirely the upper surface of the young blades of a grass.

70. *Cocomytillus isis*, Hall. This species was described by W. J. Hall from *Tamarix* in Egypt. I found only a few specimens on the branches of a *Tamarix* in a wadi near Jisr-el-Ghoraniyeh, 18.iv.1925.

71. *Pinnaspis bilobis*, Newst. Found once encrusting very heavily the stems of *Foeniculum vulgare* in a little wadi near Ain-Harod, 24.viii.1925, and this winter (xii.1925) at Huldah and Tel Aviv on the same plant.

72. *Pinnaspis zillae*, Hall. W. J. Hall described this species from *Zilla spinosa* in Egypt. It is very common in the surroundings of Jericho and Wadi Kelt, where it encrusts the branches of *Callotropis procera* and the stems of *Osyris alba*, 16-17.iv.1925. I found the same species two years ago at Wadi-es-Safiyeh, in the southern end of the Dead Sea, v.1923.

73. *Eriopeltis festucae* (Fonsc.). Typical specimens of this species were taken from *Eragrostis* sp. (Gram.) at Dilb, 24.viii.1925. The lower part of the stem was covered by the egg-laying females, and the young larvae hatched a week after the specimens had been collected. It seems that even in Palestine *Eriopeltis festucae* has only one generation a year. Perhaps this is the same species as mentioned under no. 45 (1924, p. 66).

74. *Filippia ephedrae*, Newst. Found once near Tel Aviv on *Asparagus stipularis*, 20.ii.1926 (Naftolsky).

# 75. *Pulvinaria pistaciae*, sp. n. (figs. 1, 2).

Dried specimens of the adult female approximately circular (fig. 1, A) with a distinct, raised, short oval area showing transverse wrinkles. Colour light red-brown and dark brown in the raised middle area. Ovisac (fig. 2) large, elliptic, with a uniform rough surface. Length of ovisac 3.8-4.9 mm., breadth 2.8-4.2 mm.

Antennae (fig. 1, B) of adult female eight-jointed, the length of the joints somewhat variable. The length for the antennal joints (taken from 5 right antennae) is



as follows: Joint i,  $54-63\mu$ ; ii,  $66-72\mu$ ; iii,  $69-75\mu$ ; iv,  $63-75\mu$ ; v,  $45-51\mu$ ; vi,  $27-30\mu$ ; vii,  $24-27\mu$ ; viii,  $51-54\mu$ .

Legs well developed. Tarsi of the middle and hind legs half as long as the tibiae, of the fore legs two-thirds of the tibiae. Claws stout, normal.

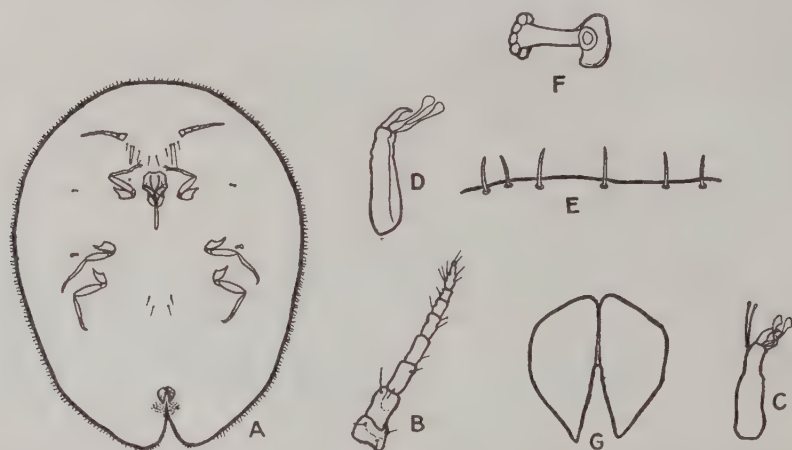


Fig. 1. *Pulvinaria pistaciae*, sp. n.: A, adult ♀; B, antenna; C, tarsus and claw of front leg; D, same of hind leg; E, marginal spines; F, spiracle; G, anal operculum. (A  $\times 16$ , B-G  $\times 128$ ).



Fig. 2. *Pulvinaria pistaciae*, sp. n., adult ♀ with ovisac.  $\times 5$ .

Margin closely set with spines (fig. 1, E), stigmatic spines absent.\* Spiracles (fig. 1, F) small. Rostral loop very short. Valves of the anal operculum (fig. 1, G) with base somewhat shorter than the outer edge. Five hairs (2 short and 3 longer ones) on each side below and between the insertion of the antennae, and two hairs

\*Mr. F. Laing, of the British Museum, kindly informs me that in one of the specimens that I have sent him he has found well-defined stigmatic spines which are very short and conical.

between and below the insertion of the hind legs. Below the valves on each side a group of small glandular openings.

Length of adult female, 2.7–3.1 mm. ; breadth, 2.5–2.9 mm.

The specimens were collected on Mount Kanaan (Upper Galilee, near Safed, 21.v.1925) from the lower surface of the leaves and from the twigs of *Pistacia palestina* (E. Eig).

76. *Naiococcus serpentinus* var. *minor*, Green. This conspicuous species was taken at Jisr-el-Ghoraniyeh from *Tamarix* sp., 25.viii.1925. It is not uncommon, but never appears in more than one or two specimens on the smaller branches. The species, originally described by Green from Persia and Baluchistan, has recently also been discovered by W. J. Hall near Suez.

77. *Pseudococcus adonidum* (L.). This species caused a heavy infestation on *Spartanum africana* in a private garden at Jerusalem (Mrs. Fodor), vii.–viii.1924. It seems to be a new introduction into Palestine.

#### 78. *Pseudococcus daganiae*, sp. n. (figs. 3, 4).

Adult female (fig. 3, A), elongate ovate, of a lemon-yellowish colour, markedly covered with mealy secretory matter. Marginal filaments have not been observed. Length, 1.5–2.2 mm. ; breadth, 0.9–1.25 mm.

Antennae of adult female (fig. 3, B–D) very variable ; normally eight-jointed, but seven-jointed antennae are not uncommon. The relative lengths of the joints very variable in joints 2–5. The terminal joint is the longest, the first and second joint being generally the next in length.

*Length of Antennal Joints in  $\mu$ .*

Joints.	1.		2.	3.	4.
	Left.	Right.			
1 ... ..	45	45	45	45	45
2 ... ..	45	45	54	75	48
3 ... ..	63	42	36	—	36
4 ... ..	—	27	27	30	30
5 ... ..	36	27	27	27	30
6 ... ..	27	27	27	30	30
7 ... ..	33	30	30	33	30
8 ... ..	75	75	75	81	72
Total length...	324	318	321	321	318

The reduction of the number of antennal joints has originated through the fusion of joints 3 and 4, or of joints 2 and 3. Asymmetry is not uncommon as in No. 1 of the table where the left antenna is seven-jointed and the right eight-jointed.

Limbs well developed. The tibiae of the hind pair of limbs (fig. 3, E) subequal to the femora and about twice the length of the tarsi. Anterior and posterior osteoles conspicuous. Cerarii consisting of a number of short spines, surrounded by pores.\*

\* I am indebted to Mr. Laing for the following remarks : " The material is not mature, but certain characters are available for comment. So far as I can make out, there are but three pairs of cerarii, the two anterior to the last very weakly defined, and the two spines on each cerarius rather remote from each other. Single spines may mark the position of some of the other cerarii, but for practical purposes they must be regarded as non-existent. Though the body-spines are small, they appear to me to be somewhat lanceolate in shape. . . . The species should be placed in the genus *Trionymus* rather than in *Pseudococcus*."

Anal cerarii arranged in two rows. Anal ring large with six short setae. Caudal setae stout and short, not twice as long as those of the anal ring. Rostral loop very short, not reaching the insertion of the mid pair of limbs. Derm covered with short

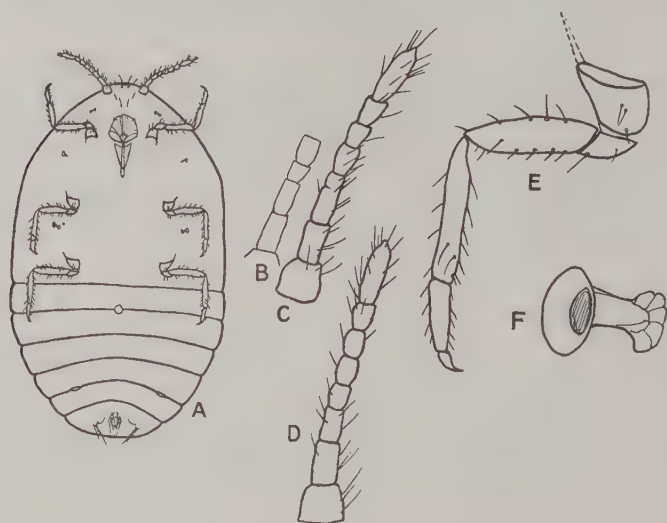


Fig. 3. *Pseudococcus daganiae*, sp. n. : A, adult ♀; B, C, D, different types of antennae; E, hind leg; F, spiracle. (A  $\times 30$ , B-E  $\times 128$ , F  $\times 255$ )

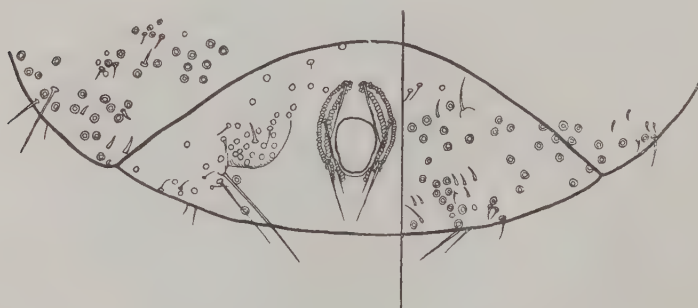


Fig. 4. *Pseudococcus daganiae*, sp. n., posterior extremity of adult ♀,  $\times 190$ .

hairs and trilocular pores. Many large ring-shaped pores ventrally situated on the posterior abdominal segments. Frons between the insertion of the antennae with one longer and one shorter hair on each side.

79. *Pseudococcus variabilis*, Hall. W. J. Hall records this species from the root and stem of *Panicum colonum* at Jaffa (Min. Agr. Egypt, Bull. 46, 1924, pp. 5-6, pl. 4, fig. 6a).

## NOTES ON AUSTRALIAN TABANIDAE (DIPTERA).

By FRANK H. TAYLOR,

*Australian Institute of Tropical Medicine, Townsville.*

The following notes are the result of correspondence between Major E. E. Austen, of the British Museum, and myself concerning certain specimens of the family TABANIDAE that were sent to him some time ago for critical notes, which are quoted below. It is a pleasure to thank him for having on several occasions given me the benefit of his extensive knowledge of the Diptera.

## Subfamily PANGONIINAE.

**Chrysops australis**, Ricardo.

*C. australis*, Ric., Ann. Mag. Nat. Hist., (8) xvi, p. 265, 1915.

The Institute possesses two specimens, one collected by Mr. F. P. Dodd, the other by myself, which has been compared with the paratype in the British Museum.

QUEENSLAND: Kuranda (*F. P. Dodd*), Meringa (*F. H. Taylor*).

**Silvius distinctus**, Taylor.

*S. distinctus*, Tayl., Proc. Roy. Soc. Victoria, xxxii (N.S.), pt. 2, p. 165, 1920.

"The species is quite distinct from any other known to me" (Austen).

NORTHERN TERRITORY: Bathurst Island (type locality).

## Subfamily TABANINAE.

**Udenocera australis**, Ricardo.

*Acanthocera australis*, Ric., Ann. Mag. Nat. Hist., (8) xvi, p. 16, 1915.

"Species No. I (Cairns, 'swept from foliage of *Eugenia* sp.,' and Kuranda) is *Udenocera australis*, Ric., which was erroneously placed by its author in the genus *Acanthocera*, Macq." (Austen).

The distribution of the genus *Udenocera* is interesting. *U. brunnea*, Ric., the type of the genus, comes from Ceylon; another species of the genus is *Chrysops parallelus* (Walk.) Ric. (1915), which comes from Batjan Island; and the present species, *U. australis*, Ric., from North Queensland.

I have deposited the specimen taken by myself in the Institute Collection.

**Tabanus kendallensis**, Taylor.

*T. kendallensis*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 68, 1919.

"*Tabanus kendallensis*, Taylor, is *T. oculatus*, Ric. (Ann. and Mag. Nat. Hist., Series 8, Vol. xvi, p. 276, 1915)" (Austen).

**Tabanus minor**, Taylor.

*T. minor*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 64, pl. i, f. 8, 1919.

"*Tabanus minor*, Taylor (nec Macq.—*T. palmerstoni*, Ferg. & Hill) is *T. constans*, Walker (List. Dipt. Inst. in coll. Brit. Mus., i, p. 186, 1848). Walker's description is misleading as well as inadequate. His type had evidently been preserved in fluid before being pinned, and this had altered its appearance considerably; for instance, the 'bright tawny' colour of the hair on the underside of the head is not natural" (Austen).



***Tabanus hilli*, Taylor.**

*T. hilli*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 64, 1919.

"*Tabanus hilli*, Taylor, is *T. neogermanicus*, Ric. (Ann. and Mag. Nat. Hist., Ser. 8, Vol. xv, p. 283, 1915), by comparison of paratype of former with type of latter. According to a MS. note by Miss Ricardo, *Tabanus fugitivus*, Taylor, also = *T. neogermanicus*, Ric." (Austen).

***Tabanus obscurilineatus*, Taylor.**

*T. obscurilineatus*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 54, pl. i., f. 3, 1919.

"*T. obscurilineatus* is distinct from any other species represented in the Museum collection" (Austen).

***Tabanus walteri*, Taylor.**

*T. walteri*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 48, pl. i., f. i, 1919.

"*T. walteri*, Taylor, is *T. queenslandii*, Ric. (Ann. and Mag. Nat. Hist., Ser. 8, Vol. xiv, p. 393, 1914), by comparison of paratype of former with type of latter" (Austen).

***Tabanus batchelor*, Taylor.**

*T. batchelor*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 58, pl. ii., f. 6, 1919.

"*T. batchelor*, Taylor, is distinct from any other species represented in the Museum Collection. It is allied to, and in general appearance resembles, *T. diminutus*, Walk. (List. Dipt. Ins. in coll. Brit. Mus., i, p. 183, 1848), the type of which is from Port Essington. In the female sex, however, *T. batchelor* is distinguished from the species mentioned *inter alia* by the colouration of the front legs, which are not ochraceous-tawny, with the tarsi merely brown except at the base; and by the veins or portions of veins in the centre of the wing being suffused with brownish" (Austen).

***Tabanus eidsvoldensis*, Taylor.**

*T. eidsvoldensis*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 49, pl. ii., f. 2, 1919.

"*Tabanus eidsvoldensis*, Taylor, does not agree with any other species in the Museum; the markings on the dorsum of the abdomen resemble those exhibited by the type of *T. lunulatus*, Big., but in other respects the two species are quite distinct" (Austen).

There is also a superficial resemblance to *T. circumdatus*, Walker, from which, however, the present species is quite distinct, *inter alia* owing to its eyes being bare.

***Tabanus atmophorus*, Taylor.**

*T. atmophorus*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 59, pl. i., f. 7, 1919.

"*T. atmophorus*, Taylor—not hitherto represented in the Museum collection nor otherwise known to me" (Austen).

***Tabanus brisbanensis*, Taylor.**

*T. brisbanensis*, Tayl., Proc. Linn. Soc. N. S. Wales, xlv, p. 526, 1917; op. cit., xlv, p. 67, pl. ii, figs. 10, 11, 1919.

"*T. brisbanensis*, Taylor—not hitherto represented in the Museum collection, nor otherwise known to me" (Austen).

Ferguson & Hill (Proc. Linn. Soc. N. S. Wales, xlv, p. 466, 1920) place this species as a synonym of *T. regis-georgii*, Macq., but in view of Austen's note it must be restored to specific rank.

**Tabanus geraldtonensis**, Taylor.

*T. geraldtonensis*, Tayl., Proc. Linn. Soc. N. S. Wales, xliv, p. 70, pl. i., f. 12, 1919.

"*T. geraldtonensis*, Taylor—not hitherto represented in the Museum collection, nor otherwise known to me" (Austen).

**Tabanus kurandae**, Taylor.

*T. kurandae*, Tayl., Proc. Linn. Soc. N. S. Wales, xliv, p. 58, pl. i., f. 5, 1919.

"*T. kurandae*, Taylor, is *T. innotabilis*, Walk. (List. Dipt. Ins. in coll. Brit. Mus., i, p. 177, 1848), by comparison of specimen with Walker's type" (Austen).

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## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology between 1st April and 30th June, 1926, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

ALBANY MUSEUM, GRAHAMSTOWN :—55 Orthoptera ; from South Africa.

Mr. T. J. ANDERSON, Government Entomologist :—47 Lepidoptera ; from Kenya Colony.

Dr. G. ARNOLD, Rhodesia Museum :—6 Tabanidae, 108 other Diptera, 56 Coleoptera, and 39 Rhynchota ; from Rhodesia.

Mr. E. BALLARD, Commonwealth Cotton Entomologist :—86 Parasitic Hymenoptera, 2 other Hymenoptera, 9 Lepidoptera, 6 Thysanoptera, and 131 Rhynchota ; from Queensland, Papua, and New Guinea.

Dr. C. F. C. BEESON, Forest Entomologist :—47 Curculionidae ; from Dehra Dun, India.

Mr. LL. E. W. BEVAN :—24 Diptera and 20 pupa cases ; from Southern Rhodesia.

Dr. G. BONDAR :—63 Coleoptera and 2 larvae, 18 Parasitic Hymenoptera, 4 Lepidoptera, and a sample of cotton stems and roots attacked by *Gasterocerodes gossypii* ; from Brazil.

Mr. H. E. BOX :—12 Parasitic Hymenoptera and 4 Orthoptera ; from Venezuela.

Dr. P. A. BUNTON, London School of Hygiene and Tropical Medicine :—3 Siphonaptera, 28 *Simulium*, 11 *Culicoides*, 32 *Glossina*, 10 other Diptera, 38 Coleoptera, 3 Lepidoptera, 200 Mallophaga, 100 Anoplura, 3 Ticks, and 500 Mites ; from various localities.

Mr. H. S. CHANG :—35 Orthoptera ; from China.

Mr. L. D. CLEARE, Junr., Government Economic Biologist :—7 Diptera, 8 Coleoptera, 25 Parasitic Hymenoptera, 3 species of Aphidae, 2 other Rhynchota, 65 Mallophaga, 4 Spiders, 9 Woodlice, 3 Fish, 2 Lizards, 2 Starfish, and 5 Shells ; from British Guiana.

Mr. G. S. COTTERELL :—19 Diptera, 29 Coleoptera and 6 early stages, 21 Parasitic Hymenoptera, 4 Lepidoptera, 2 species of Aphidae, 2 species of Coccidae, 8 Psyllidae, and 4 other Rhynchota ; from the Gold Coast.

Mr. C. H. CURRAN :—21 Coleoptera and 2 Lepidoptera ; from North America.

DIVISION OF ENTOMOLOGY, PRETORIA :—7 Phoridae, 265 Coleoptera, 79 Parasitic Hymenoptera, and 11 Rhynchota ; from South Africa.

Mr. P. R. DUPONT :—9 Lepidoptera and 11 species of Coccidae ; from the Seychelles.

MESSRS. F. D. GOLDING and A. W. J. POMEROY :—34 Diptera, 58 Coleoptera, 10 Parasitic Hymenoptera, 107 Lepidoptera, 23 Rhynchota, 3 Orthoptera, and 3 Odonata ; from Southern Nigeria.

Mr. C. C. GOWDEY, Government Entomologist :—11 Tabanidae, 18 other Diptera, 71 Coleoptera and 5 larvae, 101 Hymenoptera, 14 Isoptera, 4 species of Aphidae, 5 species of Coccidae, and 29 other Rhynchota ; from Jamaica and Colombia.

Mr. G. L. R. HANCOCK, Assistant Entomologist :—7 Diptera, 139 Coleoptera, 45 Hymenoptera and a number of Braconid cocoons, 11 Lepidoptera, 1 species of Aphidae, 1 species of Coccidae, 67 other Rhynchota, 132 Orthoptera, and 4 Planipennia ; from Uganda.

Mr. E. HARGREAVES, Government Entomologist :—2 Tabanidae, 13 other Diptera, 158 Coleoptera, 50 Parasitic Hymenoptera, 6 other Hymenoptera, 44 Lepidoptera, 3 species of Coccidae, 91 other Rhynchota, 7 Orthoptera, 6 Planipennia, 2 Trichoptera, and 100 Mites ; from Sierra Leone.

Mr. H. HARGREAVES, Government Entomologist :—3 Culicidae, 5 Tabanidae, 47 other Diptera, 186 Coleoptera, 200 Parasitic Hymenoptera, 268 other Hymenoptera, 8 Lepidoptera, 20 Isoptera, 3 species of Aphidae, 3 species of Aleurodidae, 32 species Coccidae, 32 other Rhynchota, and 9 Collembola ; from Uganda.



- Mr. M. AFZAL HUSAIN, Government Entomologist :—7 Parasitic Hymenoptera, 4 species of Aleuroididae, and 1 species of Coccidae ; from Punjab, India.
- IMPERIAL FORESTRY INSTITUTE, OXFORD :—97 Coleoptera ; from Asia.
- Dr. A. INGRAM :—182 Siphonaptera and 188 Mites ; from South Africa.
- Mr. O. B. LEAN :—3 Culicidae, 3 Nycteribiidae, 7 other Diptera, 4 Coleoptera, 3 Lepidoptera, 54 Thysanoptera, and 2 Orthoptera ; from Southern Nigeria.
- Mr. S. LEEFMANS :—9 Coleoptera ; from Java.
- Mr. J. G. MYERS :—1 Weevil ; from Cuba.
- Mr. R. K. NARIMAN :—4 Rhynchota ; from Punjab, India.
- NATAL MUSEUM, PIETERMARITZBURG :—3 Orthoptera ; from South Africa.
- NATIONAL MUSEUM, MELBOURNE :—34 Rhynchota ; from Australia.
- Mr. W. H. PATTERSON, Government Entomologist :—635 Isoptera ; from the Gold Coast.
- Mr. A. S. PEARSE :—6 Lepidoptera, 4 larvae, and 7 cocoons ; from Colombia.
- Mr. A. W. J. POMEROY :—84 Culicidae and 499 Isoptera ; from the Gold Coast.
- Mr. G. B. PURVIS :—43 Diptera, 103 Hymenoptera, 2 Rhynchota, and 1,709 Ticks, 30 larvae, and 100 eggs ; from Kenya Colony.
- Mr. Y. RAMACHANDRA RAO, Government Entomologist :—11 Parasitic Hymenoptera, 35 Lepidoptera, and 80 Rhynchota ; from South India.
- Mr. J. G. RHYNEHART :—7 Coleoptera ; from Ireland.
- Mr. A. H. RITCHIE, Government Entomologist :—75 Coleoptera, 100 Thysanoptera, 3 species of Aphidae, 22 species of Coccidae, and 3 Ticks ; from Tanganyika Territory.
- Mr. H. W. SIMMONDS, Government Entomologist :—7 Diptera, 254 Coleoptera, 6 Parasitic Hymenoptera, 6 other Hymenoptera, 31 Lepidoptera, 8 Rhynchota, 2 Orthoptera, 4 Spiders, and 2 Scorpions ; from the Fiji Islands.
- Miss F. M. SINKEY :—67 Coleoptera and 3 larvae, 4 Lepidoptera, 12 Rhynchota, 11 Orthoptera, 10 Perlidae, and 2 Spiders ; from China.
- Mr. O. H. SWEZEY :—11 Lepidoptera ; from Hawaii.
- Mr. C. B. SYMES :—96 Culicidae, 30 *Tabanus*, 2 *Auchmeromyia*, 36 *Glossina*, 76 other Diptera, 60 Hymenoptera, 2 Rhynchota, 4 Orthoptera, and 9 Trombididae ; from Kenya Colony.
- Mr. H. P. THOMASSET :—2 *Tabanus*, 14 other Diptera, 46 Coleoptera, 52 Hymenoptera, 57 Lepidoptera, 24 Rhynchota, 3 Orthoptera, and 2 *Peripatus* ; from Natal.
- Mr. A. TONNOIR :—2 species of Aphidae ; from New Zealand.
- WELLCOME TROPICAL RESEARCH LABORATORIES :—6 Orthoptera ; from the Sudan.
- Mr. D. S. WILKINSON :—1 Intestinal Worm ; from Cyprus.
- Mr. F. X. WILLIAMS :—153 Coleoptera and 58 Hymenoptera ; from Hawaii.
- Dr. F. ZACHER :—4 Coleoptera ; from Guatemala.

## NEW INJURIOUS CURCULIONIDAE (COL.).

By GUY A. K. MARSHALL, C.M.G., D.Sc., F.R.S.

(PLATE XIX.)

Subfamily OTIORRHYNCHINAE.

**Blosyrus batatae**, sp. n. (Pl. xix, fig. 13).

♂♀. Integument black, with brown scaling; the pronotum with two indefinite paler stripes; the elytra with vague paler markings which sometimes form a very ill-defined band across the middle, broadly interrupted at the suture.

*Head* with the forehead divided into four areas by three deep sulci, the straight median one slightly narrower than the others, which are shallow in front and much deeper behind, curving at first inwards and then transversely outwards, so as to separate the lateral areas from the vertex; the frontal areas of approximately the same width anteriorly, the median pair broader in front than behind and continuous with the vertex, the outer pair dilated and obtusely elevated behind, not projecting over the eyes; the surface, when denuded of scales, with numerous minute punctures and sparse larger ones; the eyes strongly convex, deepest behind the middle. *Rostrum* transverse (3:2), almost parallel-sided, the transverse basal incision very broad and deep; the dorsum with a low median carina which begins to fork at or a little beyond its middle, and which at the base is as high as the narrowly separated areas on each side of it; adjoining the carina a more or less deep curved impression, and a shallow oblique furrow on each side in the basal half; the posterior margin of the epistome not higher than the median carina. *Antennae* with joint 1 of the funicle twice as long as 2, 3-7 a little longer than broad, 3-5 of equal width, 6 and 7 each becoming wider. *Prothorax* transverse (8:5), very strongly rounded (almost obtusely subangulate) at the sides, widest well before the middle, and scarcely constricted near the apex; the apical margin truncate or shallowly sinuate, the base truncate; the dorsum very convex longitudinally, highest at the middle, coarsely and confluent foveate, and with an abbreviated low median carina; the scales small, subcircular and closely placed; the setae short, scale-like and recumbent. *Elytra* subquadrate, very nearly as broad as long, truncate at the base, convexly sloping thence to the rather sharp subhumeral projection (on interval 9—somewhat more prominent in ♀), parallel-sided from there to beyond the middle, and very broadly rounded behind, the base not vertically truncate but sloping very steeply; the striae rather broad and shallow, the punctures distinct through the scaling and diminishing behind; the intervals slightly broader than the striae, convex and all of the same height, each bearing numerous irregular short scale-like recumbent setae; the scales as on the pronotum. *Legs* black, with dense brown scaling, the posterior pairs of femora with a paler patch on the clavate portion.

*Length*, 6.9-7.2 mm.; *breadth*, 3.6-3.9 mm.

TRANSVAAL: Barberton, 1.ii.1922 (G. C. Haines).

Described from 10 specimens.

Reported by the Division of Entomology, Pretoria, as defoliating sweet potato vines (*Batatas edulis*).

Allied to *Blosyrus saevus*, Boh., of the Natal Coast, but in that species the median carina of the rostrum is much lower than the areas on each side of it, and widely separated from them; the two outer furrows on the forehead are much narrower than

the median one and not curved, and the two median raised areas are much narrower than the outer ones and almost parallel-sided; the elytra with the sides quite straight from the base to the much more prominent subhumeral projection and with the alternate intervals more elevated.

**Mimaulodes hirtulus**, sp. n. (text-fig. 1).

♀. Integument black, with dark grey scaling more or less variegated with dark brown, and set with very long erect setae; the head almost uniformly grey; the pronotum with very indefinite brown stripes, a broad one in the middle and two narrow ones on each side; the elytra with very variable and irregular brown patches, the scales on interval 1 having usually a slight coppery reflection, and intervals 8 and 9 generally with a brown stripe, which is continued on the side of the prothorax; the lower surface uniform paler grey.

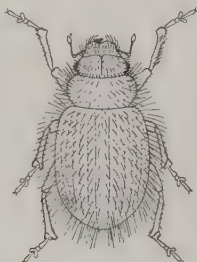


Fig. 1. *Mimaulodes hirtulus*, sp. n., ♀

*Head* rather strongly convex transversely and with a deep median sulcus that almost reaches the vertex, clothed with dense overlapping scales and set with stout curved backwardly-directed setae, which are much shorter and thicker than those on the elytra, a row along the inner margin of each eye being a little longer, straighter and thinner than the rest; the eyes almost circular, moderately convex, and not backwardly produced. *Rostrum* separated from the head by a slightly sinuate furrow, much shorter than its basal width, strongly narrowed in front, with the sides almost straight; the dorsum nearly flat, with two small shallow impressions in the middle separated by a feeble costa; the scaling and setae as on the head. *Prothorax* twice as broad as long, strongly rounded at the sides, widest at the middle; the base gently arcuate, the apex scarcely narrower than the base and shallowly sinuate; the dorsum even, strongly convex transversely and flat longitudinally, without any median stria; the setae on the disk like those on the head, the lateral ones longer and straighter, like those on the elytra. *Elytra* broadly ovate, widest about the middle, rather obtusely rounded behind, shallowly sinuate at the base, not laterally constricted at the apex; the fine shallow striae with the punctures just visible through the scaling and scarcely diminishing behind; the intervals broad and almost flat, each bearing a single row of very long pointed erect dark setae, there being a few stouter white setae irregularly scattered behind the middle; the scales dense but not overlapping, irregular in shape and like mosaic. *Legs* densely squamose and with obliquely raised setae; the scales on the basal two-thirds of the femora flat, shiny, submetallic and not overlapping, the scaling on the tibiae and apex of the femora appearing scabrous, opaque and overlapping; all the tibiae with two long black spines on the inner edge, the front pair with an apical row of 6 to 9 spines (increasing in length outwardly) and 2 more on the external edge, and the hind pair with the dorsal edge somewhat sinuate; the tarsi with a pad of soft hairs on the apical half of the underside of joint 3.

*Length*, 3.0-3.3 mm.; *breadth*, 1.7-1.8 mm.

TRANVAAL : Foothills, 7♀, 8.ix.1926 (*B. Leigh*).

Reported by the Division of Entomology, Pretoria, as injuring young melon plants.

Differs from my original description of the genus *Mimaulodes* (Ann. Mag. N.H. (9) i, 1919, p. 5) in having the upper edge of the scrobe well below the eye, and in having some soft hairs on the underside of the tarsi; the generic description must therefore be modified accordingly. The genotype, *M. fimbriatus*, Mshl., differs also, *inter alia*, in having the eyes almost flat, the prothorax much broader at the base than at the apex, the setae on the disk of the pronotum and elytra very short and broad, and the elytra with broad shallow sulci.

**Protostrophus gonoderes**, sp. n. (Pl. xix, fig. 1).

♂♀. Integument black, densely clothed with scaling, which is dark grey above, irregularly and variably mottled with light and dark brown, and paler grey beneath; in ♀, the pronotum bears a broad median dark brown stripe, and usually a very narrow broken brown line on each side of it, these being sometimes (and perhaps normally) absent in ♂; the elytra in ♀ usually with two rather prominent grey spots, one at about the middle on interval 5 and the other behind the middle on interval 3.

*Head* separated from the rostrum by a gently curved furrow and with a broad deep median sulcus, their junction forming a large deep cavity; the forehead broadly depressed, the lateral margins forming an obtuse ridge much higher than the ocular peduncle; the surface densely squamose and with subrecumbent stout brown setae; the eyes prominent and produced backwards for about half their length, the orbit not projecting on the hind margin. *Rostrum* (including mandibles) only slightly broader than long (6:5), the apical (genal) width two-thirds that of the base, the sides distinctly sinuate, the scrobes partly visible from above; the dorsum shallowly impressed in the middle and with a high bare median carina, on each side of and parallel with which is an obtuse squamose brown costa set with numerous subrecumbent setae, the lateral margins also somewhat raised and bearing many setae. *Antennae* piceous; joint 1 of the funicle half as long again as 2, 3-7 all transverse, subequal in length but 7 a little broader than the others. *Prothorax* twice as broad as long, obtusely angulated at the sides a little behind the middle and shallowly constricted at the apex; the apical margin subcarinate down the sides and deeply sinuate dorsally, the base broadly arcuate; the dorsum less convex than usual transversely and almost flat longitudinally, smooth and densely squamose except for a low bare median carina; the scales subcircular and occasionally slightly overlapping, the setae short, stout and recumbent. *Elytra* ovate, broadest before the middle, obtusely acuminate behind (more bluntly so in ♂), shallowly sinuate at the base, with the basal angles projecting more than those of the prothorax; the dorsal outline moderately convex, rising gradually to the middle and steeply declivous behind; the striae comparatively broad and deep, the punctures hidden by scaling; the intervals hardly broader than the striae and slightly convex, with numerous irregular recumbent brown setae, which on the declivity are partly replaced by suberect white ones. *Legs* black, with the tarsi piceous, densely clothed with grey and brown scaling; the front tibiae with a continuous row of closely-set apical spines, the corbels of the hind pair sparsely squamose.

*Length*, 6-6.9 mm.; *breadth*, 2.9-3.3 mm.

ORANGE FREE STATE : Bethlehem, 12.xi.1923 (*G. Clarke*).

Described from 6 specimens.

Reported by the Division of Entomology, Pretoria, as defoliating grape-vines.

Nearly allied to *P. carinirostris*, Mshl. 1920, and *P. (Strophosomus) sulcatifrons*, Mshl. 1907, but both these species differ in having numerous sulci on the forehead.



**Protostrophus consobrinus, sp. n.**

♂♀. Integument black, with variegated grey and brown scaling; the rostrum with the impressed areas pale and the elevations dark; the head brown, with grey scaling adjoining the eyes; the pronotum greyish laterally, with a rather broad and very indefinite brown median area and an indistinct narrow brown stripe on each side of it; the elytra brown, with very indefinite and variable grey spots in the striae; the lower surface grey.

*Head* with a deep median sulcus ascending to the vertex and four or five low narrow carinae on each side (normally almost concealed by the clothing), the setae broad and recumbent; the eyes very prominent laterally and strongly produced backwards (for fully half their length), moderately convex, and with the orbit not projecting behind. *Rostrum* a little shorter than its basal width, rather less narrowed in front than usual, the width of the apex being two-thirds that of the base, with the sides quite straight and the scrobes not visible from above; the dorsum with a strong, partly bare, median carina and a curved squamose costa on each side of it running from the base and joining the lateral margin at about two-thirds. *Antennae* black, the funicle with joint 1 about as long as 2 and 3, 4 to 6 bead-like and about as long as broad, 7 broader. *Prothorax* more than twice as broad as long, rather strongly rounded at the sides, widest behind the middle, deeply constricted at the apex, and with the posterior angles rounded off; the base arcuate and not marginate, the apex much narrower than the base and dorsally sinuate; the dorsum feebly convex longitudinally, with the somewhat rugose shallow punctation almost entirely hidden by the scaling, and with a narrow bare median carina not quite reaching the base or apex. *Elytra* broadly ovate, gently rounded at the sides, widest at about the middle, broadly rounded behind, the apex being concealed from above, and deeply sinuate at the base; the dorsal outline gently convex and continuous with that of the pronotum, the broad shallow sulci containing papillate punctures that are visible through the scaling; the intervals somewhat broader than the sulci, slightly convex and with numerous irregular short recumbent setae. *Legs* stout, with dense mottled grey and brown scaling; the tibiae with a rather conspicuous apical mucro, the front pair with a fairly dense row of apical spines, which continues round to the external edge, and the corbels of the hind pair squamose.

*Length*, 4.8–6.0 mm.; *breadth*, 3.0–3.6 mm.

*TRANSVAAL*: Volvehoek, 2♂♂, 2♀♀, 16.ix.1926.

Reported by the Division of Entomology, Pretoria, as feeding on young almond trees.

This species is evidently the more northern representative of *P. carinirostris*, Mshl. 1920, from Natal, which differs in having shorter, less prominent and more convex eyes; the carinae on the forehead are much more conspicuous; the costae on the rostrum are more raised and somewhat more curved, and the sides of the rostrum are sinuate.

**Protostrophus oblongus, sp. n. (Pl. xix, fig. 2).**

♂♀. Integument black, with dense light brown scaling above, the sides of the elytra (below stria 7) and the lower surface grey; the elytra sometimes more or less greyish above.

*Head* separated from the rostrum by a slightly curved short furrow and with a broad deep median sulcus; the forehead flat, densely squamose, and with short subrecumbent spatulate setae; the eyes moderately convex, only shortly produced backwards (about one-fourth their length), the hind margin rounded off. *Rostrum* broader than long (5:3), the apex two-thirds the width of the base, the sides almost straight, the scrobes not visible from above; the dorsum quite flat, without any

median carina or sulcus. *Antennae* testaceous, unicolorous; joint 1 of the funicle twice as long as 2, 3-6 moniliform, 7 transverse. *Prothorax* broader than long (4 : 3), rather strongly rounded at the sides, widest a little behind the middle, shallowly constricted at the apex; the base subtruncate, the apex feebly arcuate; the dorsum strongly convex transversely and moderately convex longitudinally, the apex being lower than the base and the greatest height behind the middle; the surface quite smooth, with a deep median stria which does not quite reach either base or apex, being broader in the basal half; the scales closely packed and differing in size and shape; the spatulate setae short and recumbent. *Elytra* oblong-ovate in ♂, more rapidly narrowed at the base in ♀, very broadly rounded behind (seen directly from above) and shallowly sinuate at the base; the dorsal outline rising very slightly at the base, then almost flat to the declivity, which is very steep above and vertical near the apex; the striae feeble, containing small separated punctures, the intervals broad, almost flat, each with a single row of small inconspicuous recumbent setae; the scales as on the pronotum. *Legs* black, with the tarsi piceous, with dense scaling which is normally brown above and grey beneath; the front tibiae with 5 or 6 stout separated spines on the apical margin; the corbels of the hind pair at least partly squamose.

*Length*, 3.9-4.8 mm.; *breadth*, 1.75-2.1 mm.

TRANSVAAL: De Wildt, 9.xii.1919.

Described from 13 specimens.

Recorded by the Division of Entomology, Pretoria, as defoliating young orange trees.

**Protothropus gulo**, sp. n. (Pl. xix, fig. 3).

♀. Integument black, with uniform grey or light brown scaling above and grey beneath.

*Head* separated from the rostrum by an indistinct short curved furrow and with a deep median sulcus; the forehead flat in the middle and sloping gradually to the eyes on each side, with dense scaling and subrecumbent spatulate setae; the eyes not very convex, produced backwards for only one-third their length, the hind margin rather sharp, but the orbit not projecting. *Rostrum* transverse (4 : 3), the apical width about five-eighths that of the base, the sides almost straight, the scrobes not visible from above; the dorsum almost flat, with a small rounded impression in the middle of the apical half, but no carinae; the clothing as on the head. *Antennae* testaceous brown; joint 1 of the funicle about twice as long as 2, 3-7 transverse and becoming progressively wider. *Prothorax* strongly transverse (7 : 4), rounded at the sides, widest at the middle, with the basal and apical angles rounded off. the base and apex subtruncate; the dorsum strongly convex transversely and almost flat longitudinally, quite smooth and with a median stria (almost concealed by scaling) in the basal half, with scaling of the mosaic type and with stout subrecumbent linear setae. *Elytra* shortly ovate, widest about the middle, broadly rounded behind (as seen directly from above), and jointly sinuate at the base; the dorsal outline almost flat in the basal half, very steeply declivous behind, and slightly retuse at the apex; the striae very shallow, and the punctures hardly visible through the scaling; the intervals broad and feebly convex, each with a row of slightly raised stout linear pale setae; the scaling mosaic-like. *Legs* black, with the tarsi piceous; the front tibiae with the outer apical angle somewhat produced, the apical margin bearing 4 stout spines, with a fifth at some distance along the outer margin; the hind corbels partly squamose.

*Length*, 3.3-3.9 mm.; *breadth*, 1.9-2.2 mm.

TRANSVAAL: Rooikraal, 18.xii.1924.

Described from 8 specimens.

Reported by the Division of Entomology, Pretoria, as very destructive to young cotton.

**Protostrophus compactus**, sp. n.

♀. Integument black, with dense pale brown scaling above, with a few scattered whitish scales; the lower surface brownish grey.

*Head* separated from the rostrum by a fine curved stria and with a broad deep median sulcus extending to the vertex; the forehead sloping gently from the middle to the eye, with slightly overlapping scales and stout, not quite recumbent setae; the eyes moderately convex, projecting backwards for about a quarter of their length. *Rostrum* a little longer than half the basal width, the apical width about equal to the length, gently sinuate at the sides, the scrobes not visible from above; the dorsum flat, with a low narrow median carina; the clothing as on the head. *Antennae* honey-coloured; joint 1 of the funicle a little longer than 2 and 3, joints 3-7 nearly as broad as long, 7 wider than the others. *Prothorax* very transverse (7:4), moderately rounded at the sides, widest at the middle, very deeply and narrowly constricted at the base, the constriction shallowly continued across the dorsum, deeply and abruptly constricted at the apex, so as to form an obtuse angulation; the apical margin feebly sinuate in the middle dorsally and hardly narrower than the base, which is subtruncate; the dorsum strongly convex transversely and gently so longitudinally, smooth and without any median stria or carina; the small scales somewhat irregular in shape and densely packed, the short spatulate setae almost recumbent. *Elytra* oblong-ovate, widest in the middle, broadly rounded behind, and subtruncate at the base, the basal angles slightly produced forwards; the dorsal outline flat from the base to beyond the middle and steeply declivous behind; the striae rather shallow, the punctures appearing small but distinct throughout, being only partly hidden by the scaling; the intervals broad and slightly convex, each with a single row of short, obliquely raised, spatulate setae; the scales shortly ovate and slightly overlapping. *Legs* piceous, with sandy grey scaling; the front tibiae with an apical row of 4 or 5 unequal spines and an isolated one on the outer edge, the hind corbels bare.

*Length*, 3.6-3.9 mm.; *breadth*, 2.1-2.25 mm.

PORTUGUESE E. AFRICA: Goba, 1♀, on cotton, 1.iii.1924 (type), and Mvamba, 1♀ on cotton, 27.iii.1924 (C. B. Hardenberg).

Belongs to the group of *P. amplicollis*, Fhs. 1871, and *P. immerens*, Mshl. 1919, both of which can be distinguished by the entirely recumbent and inconspicuous setae on the upper surface.

**Protostrophus ocularius**, sp. n. (Pl. xix, fig. 6).

♂♀. Integument black, with uniform sandy-grey scaling above and below.

*Head* with a deep median sulcus and separated from the forehead by a strongly curved furrow; the shallow punctation hidden by the scaling, the setae subspatulate and slightly raised; the eyes very prominent and produced backwards for nearly two-thirds their length, deepest behind the middle, rounded on the posterior edge, the orbit not being produced. *Rostrum* broader than long (3:2), with the apex about half as wide as the base and the sides sinuate, the scrobes visible from above, the dorsum with a median impression containing a low squamose carina and bounded on each side by a broad costa, these costae dividing the base into three approximately equal portions; the sculpture and clothing like that of the head. *Antennae* red-brown, with the club paler; joint 1 of the funicle half as long again as 2, 3-5 subequal and a little longer than broad, 6 and 7 each becoming a little longer and broader. *Prothorax* transverse (3:2); the anterior angles sinuated for the reception of the projecting eyes, the situation bounded posteriorly by a projecting short vertical carina; the hind angles also sinuated, the anterior end of the situation being produced into a stout laterally-projecting tooth; the basal margin feebly arcuate, the apex shallowly sinuate in the middle; the dorsum strongly convex transversely and slightly so longi-



tudinally, the feeble punctation entirely hidden by the contiguous, but not overlapping, circular scales, leaving bare a low median carina that does not quite reach either base or apex; the setae like those on the head. *Elytra* ovate, broadest before the middle, rather obtusely acuminate behind in ♂, a little more sharply so in ♀; the basal margin sinuate, the external angles projecting obtusely forwards and outwards; the striae very feeble, especially in ♂, the punctures being almost concealed by the scaling but discernible by the contained minute recumbent seta; the intervals broad and flat or feebly convex; the scales subcircular, dense and slightly overlapping; the setae in a single row on each interval, longer than those on the pronotum, stout, not spatulate, and recumbent. *Legs* with the apical spines on the front tibiae small and inconspicuous, the hind tibiae with the corbels bare.

*Length*, 3.9–4.8 mm.; *breadth*, 1.8–2.4 mm.

TRANSVAAL: Naboomspruit, xii.1925.

Described from 11 specimens.

Reported by the Division of Entomology, Pretoria, as attacking ground-nuts (*Arachis hypogaea*).

Allied to *P. vorax*, Mshl. (Bull. Ent. Res. xvi, 1925, p. 69, pl. i, fig. 4), but in that species the rostrum lacks the two discal costae; the eyes are much less produced; the prothorax is differently shaped and has a short median furrow in the basal half; the basal angles of the elytra project strongly forwards, etc.

### **Protostrophus cognatus**, sp. n.

♂♀. Integument black, with uniform sandy-grey scaling above and below, sometimes having a slight metallic reflection.

Very closely allied to *P. ocularius*, sp. n., and differing principally in the following characters: *Head* with the median furrow a little broader and deeper; the eyes much more convex and much less prominent, projecting for less than half their length. *Rostrum* (8:5) shorter, much less narrowed in front, the apex more than half the basal width, the sides less sinuate, and the scrobes not visible from above; the dorsum quite flat, with a sharper median carina, and quite lacking the two longitudinal costae. *Prothorax* not sinuated at the anterior angles and without the vertical carinae.

*Length*, 3.9–4.5 mm.; *breadth*, 1.8–2.1 mm.

PORTUGUESE E. AFRICA: Polana, 1♂, 1♀, 22.iii.1923 (*C. B. Hardenberg*—type); Xenga, 2♀♀, on cotton, 21.iii.1924 (*Hardenberg*).

### **Protostrophus gonocnemis**, sp. n. (Pl. xix, fig. 7).

♀. Integument black, with uniform grey scaling above and below, but sometimes with a faint darker patch in the middle of the pronotum.

*Head* with a deep median sulcus and separated from the rostrum by a moderately sinuate furrow which almost reaches the eyes, the lateral constriction behind the eyes continued faintly across the disk; the scales dissimilar in shape, subtetragonal and closely packed (like mosaic); the setae elongate, stout, yellowish and recumbent; the eyes moderately prominent and produced backwards for about half their length, deepest somewhat behind the middle, the hind margin forming a sharp edge, but the orbit not projecting. *Rostrum* broader than long (3:2), the apex two-thirds the width of the base, the sides shallowly sinuate, the scrobes not visible from above; the dorsum quite flat, with a feeble median squamose ridge terminating at the apex in a small shallow fovea; the clothing as on the head. *Antennae* testaceous, the scape rather darker; joint 1 of the funicle half as long again as 2, 3–5 subequal and slightly longer than broad, 6 and 7 each a little longer and broader. *Prothorax* twice as broad



as long, strongly rounded at the sides, widest and subangulate about the middle; the basal angles deeply, the apical ones more shallowly sinuate; the much submerged basal margin truncate, the apex feebly sinuate in the middle; the dorsum markedly convex longitudinally, the base being on a much lower level than the apex, without any median furrow or carina, the whole surface with dense mosaic-like scaling and short recumbent setae (much shorter than those on the head). *Elytra* ovate, broadest before the middle, obtusely acuminate behind, subtruncate at the base, but the external angles projecting slightly forwards in a small tubercle; the dorsal outline rising rather steeply from the base, then moderately convex, the posterior declivity very steep above and perpendicular near the apex; the striae well marked and containing small shallow separated punctures that are partly hidden by scaling; the intervals broad and convex, each with a single row of spatulate setae, which are short and recumbent near the base and become longer and somewhat raised behind; the scaling mosaic-like, as on the pronotum. *Legs* black, with dense grey scaling and subrecumbent squamiform setae; the front tibiae bent inwards and widened at the apex, thus forming a sharp angle on the outer edge that bears an isolated clump of short spinose setae; the corbels of the hind tibiae bare.

*Length*, 4.5–4.75 mm.; *breadth*, 2.4 mm.

*ZULULAND*: Empangeni, 22.xi.1921 (R. H. Harris).

Described from 6 specimens.

Forwarded by the Division of Entomology, Pretoria, and recorded as damaging beans.

Easily recognisable by the characteristic shape of the prothorax (see figure) and the external angulation of the front tibiae.

### ***Protostrophus crinitus*, sp. n. (Pl. xix, fig. 8).**

♂. Integument black, densely covered with pale scaling having a strong brassy or slightly coppery reflection, the elytra with very indefinite darker and paler markings in the striae.

*Head* separated from the rostrum by a rather broad curved furrow and with a deep median sulcus; the forehead flattened in the middle and separated on each side from the eyes by a broad shallow impression; the scales narrowly separated, the setae long, flattened and sloping backwards; the eyes moderately convex, projecting backwards for nearly half their length, the hind margin of the orbit acutely prominent. *Rostrum* (including mandibles) broader than long (4 : 3), with the sides almost straight, the scrobes not visible from above; the dorsum almost flat, with a continuous median carina, which is broader in the basal half; the clothing as on the head. *Antennae* piceous; joint 1 of the funicle a little longer than 2 and 3, 3 to 6 all slightly longer than broad and subequal, 7 longer. *Prothorax* nearly twice as broad as long, strongly rounded (almost subangulate) at the sides, widest behind the middle, broadly but shallowly sinuate at the anterior angles, and more deeply sinuate laterally at the base; the basal margin truncate and hardly wider than the apex, which is also truncate; the dorsum fairly strongly convex transversely and gently convex longitudinally, the surface even, with a flattened bare median carina from the base almost to the apex; the scaling and setae as on the head, the latter arising from shallow punctures. *Elytra* broadly ovate, widest about the middle, obtusely acuminate behind, truncate at the base, with the basal angles rounded off; the dorsal outline moderately convex, the declivity steep above and perpendicular near the apex; the striae well-marked and containing rather large distinct punctures, which become much smaller behind; the intervals broad and slightly convex, bearing numerous long erect setae, which form a single row on intervals 1 and 2, but are more or less duplicated on the other intervals;

the scales small, shiny, convex, nearly circular, closely placed but not overlapping. *Legs* black, rather thinly squamose and with short recumbent setae, the tarsi reddish brown; the femora with an indefinite whitish dorsal patch on the clavate portion and with sparse longer suberect setae on the lower surface; the front tibiae straight and with very short inconspicuous spines along the apical margin and none on the outer margin, the hind tibiae with the corbels bare.

*Length*, 4.2 mm.; *breadth*, 2.1 mm.

TRANSVAAL: Pietersburg, 1 ♂, 27.xii.1924.

Reported by the Division of Entomology, Pretoria, as attacking monkey nuts (*Arachis hypogaea*) and cotton.

Its distinctively shaped thorax, metallic scaling and long erect setae should make this species easily recognisable.

**Protostrophus vastator**, sp. n. (Pl. xix, figs. 4, 9).

♂♀. Integument black, the elytra and the pronotum with light brown scaling, the lower surface grey; the elytra with a very indefinite greyish stripe between striae 4 or 5 and 7, and sometimes with the dorsum mottled with grey or entirely grey.

*Head* separated from the rostrum by a curved furrow that nearly reaches the lateral margins and with a broad deep median sulcus; the forehead shallowly depressed in front on each side of the median sulcus, the lateral margins sloping slightly down to the eyes; the scales rather sparse and isolated in front, but contiguous on the vertex, the setae elongate, flattened and subrecumbent; the eyes not very prominent and produced backwards for only one-eighth of their length, the hind margin rounded off. *Rostrum* (including the prominent mandibles) only slightly broader than long (10:9), the apical width 0.7 of the base, the sides gently sinuate, the scrobes not visible from above; the dorsum more or less deeply impressed in the middle and with a strong continuous median carina; the scales not contiguous, the setae very short and scale-like. *Antennae* piceous; joint 1 of the funicle half as long again as 2, 3-7 all a little longer than broad and gradually increasing in width. *Prothorax* transverse (3:2), strongly rounded at the sides (especially in ♂) widest at the middle, shallowly constricted at the apex and strongly constricted at the base; the basal margin strongly elevated and feebly arcuate, not broader than the apex, which is truncate; the dorsum very convex transversely and distinctly convex longitudinally, the base being on a lower level than the apex, the whole surface even, with an abbreviated flattened median carina; the scales oval, not very dense, the integument being visible here and there; the setae small, scale-like, recumbent and inconspicuous. *Elytra* ovate, widest well before the middle, acuminate behind (more so in ♂), and shallowly sinuate at the base; the dorsal outline moderately convex, highest about the middle, and steeply declivous behind; the striae shallow, the punctures distinct near the base and becoming much shallower behind, not concealed by the scaling; the intervals broad and almost flat, each with numerous irregular setae, which are short, flattened and closely appressed; the scales small, oval and contiguous. *Legs* black, with the tarsi piceous, and with dense grey scaling; the front tibiae with a regular close row of spines at the apex, the hind corbels bare.

*Length*, 4.5-6.9 mm.; *breadth*, 1.8-3.3 mm.

TRANSVAAL: Zondernaam, Zoutpansberg, 1 ♂, 2 ♀♀, 22.iii.1911 (C. B. Hardenberg); Malipsdrift, 3 ♂♂, 23 ♀♀, 16.i.1926 (J. C. Fauve); Pietersburg, 1 ♂, 1 ♀, 27.xii.1924; Pietpotgietersrust, 1 ♂, 6 ♀♀, 30.xi.1923 (type).

Reported by the Division of Entomology, Pretoria, as having destroyed much young cotton, and also as damaging tobacco, sweet potatoes, monkey nuts and maize.

**Protostrophus latirostris**, sp. n. (Pl. xix, fig. 11).

♂♀. Integument black, with sandy brown or dark brown scaling above and more greyish beneath; the pronotum with an indefinite broad darker median stripe and often a narrow curved (frequently interrupted) dark stripe on each side and another on the pleurae; the elytra with the striae variegated with numerous paler spots.

*Head* separated from the rostrum by a strongly curved and broadly impressed furrow that almost reaches the lateral margins, and with a broad deep median sulcus; the forehead almost flat, only slightly above the level of the top of the eyes and separated from them by a shallow longitudinal furrow, and set with obliquely raised long stout setae, which are often arranged in 7 or 8 almost regular rows; the eyes very prominent, produced backwards for a little less than half their length, the hind margin rounded off. *Rostrum* somewhat transverse (5 : 4), the apical width 0.85 of the basal width, the sides strongly sinuate, the scrobes not visible from above; the dorsum shallowly impressed in the middle, with a low longitudinal squamose elevation in the middle of the base, the lateral margins in front somewhat dilated above the scrobes; the setae as on the head. *Antennae* black; joint 1 of the funicle half as long again as 2, 3 as long as broad, 4-7 transverse and becoming progressively wider. *Prothorax* much broader than long (9 : 5), strongly rounded at the sides, widest at the middle, scarcely constricted at the apex, the basal and apical margins truncate; the dorsum strongly convex transversely, nearly flat longitudinally, quite smooth, with a mere trace of a median carina, which is normally hidden by the scaling; the scales almost circular and slightly overlapping, the setae numerous, long, flattened and recumbent. *Elytra* ovate, broadest before the middle, obtusely acuminate behind and very shallowly sinuate at the base; the dorsal outline convex, rising from the base to the middle, then sloping rather steeply, and perpendicular at the apex; the striae broad and comparatively deep, the punctures nearly hidden by the scaling; the intervals scarcely broader than the striae, slightly convex, with numerous setae like those on the pronotum but rather more raised, forming approximately two rows on the disk and one on the declivity; the scales as on the pronotum. *Legs* black, the scaling mainly brown above and grey beneath; the front tibiae with a close regular row of apical spines, the corbels of the hind pair bare.

*Length*, 4.8-5.7 mm.; *breadth*, 2.4-3 mm.

TRANSVAAL : Wolvehoek, 16.ix.1926 (type). ORANGE FREE STATE : Bethlehem, 25.ix.1922.

Described from 26 specimens.

Reported by the Division of Entomology, Pretoria, as destroying rose bushes and young fruit-trees.

**Iphisomus ignavus**, sp. n.

♀. Integument black, covered with brownish grey scaling, more or less mottled with blackish scales, the prothorax usually with a very indefinite broad darker stripe on each side and below it a narrower pale stripe; the elytra sometimes with a faint paler stripe on the basal third of interval 3.

*Head* slightly flattened in the middle of the vertex, densely squamose and with the median furrow continued to well behind the eyes, the forehead flat transversely; the eyes rather strongly convex. *Rostrum* (without mandibular appendages) as long as its basal width, slightly narrowed from the base to the middle and thence parallel-sided, briefly declivous at the apex, with a large subquadrate dorsal impression containing a deep median stria, and an obtuse lateral costa on each side; the antecular area rugose and not striolate, the apical area not impressed and limited behind by a faint angulated costa; the mandibular appendages persistent, nearly as long as the rostrum, stout, coarsely rugose, incurved at the apex, and set with long setae.



*Antennae* red-brown, with the scape reaching the middle of the eye; joint 1 of the funicle as long as 2 and 3, joints 3-7 elongate and clavate. *Prothorax* transverse (4:3), strongly rounded at the sides, widest near the base, shallowly constricted near the apex, and very deeply constricted at the base itself, which is carinate, truncate and about as wide as the apex; the dorsum moderately convex transversely and longitudinally, the highest point being behind the middle, rugosely punctate, but with the sculpture mainly hidden by the scaling and with a deep median stria from the basal constriction almost to the apex; the setae subrecumbent, short, broad and truncate. *Elytra* ovate, strongly rounded at the sides, widest at about the middle, obtusely acuminate behind and without any ante-apical constriction; the dorsal profile very convex, highest at about the middle; the fine shallow striae with shallow separated punctures, which are deeper close to the base; the intervals broad and almost flat, the sculpture quite hidden by the scaling; interval 1 not elevated, and no humeral prominence; the scales closely placed, irregular in size and shape, mosaic-like; each interval with a single row of broad suberect whitish setae, longer than those on the pronotum. *Legs* with dense grey and whitish scaling and short recumbent setae; the front femora much thicker than the others; the front tibiae somewhat curved inwards at the apex and with the usual stout teeth internally, the other pairs not denticulate.

*Length*, 4.5-6.0 mm.; *breadth*, 2.1-2.5 mm.

TRANSVAAL: Acornhoek, 5 ♀♀, 17.i.1926 (T. C. Cairns); PORTUGUESE EAST AFRICA: Xinavane, 1 ♀, 2.x.1922 (C. B. Hardenberg).

Reported by the Division of Entomology, Pretoria, as damaging seedling cotton.

This insect differs from all the previously described South African species of *Iphisomus* and agrees with the East African *I. falciger*, Gerst., in its persistent mandibular appendages, the absence of the inner pair of carinae on the rostrum, and in having the base of the prothorax as narrow as the apex. *I. falciger* differs from it, *inter alia*, in its apically narrowed rostrum, less convex eyes, elevated elytral suture, rounded elytral scales, and in having the two basal joints of the funicle equal and a humeral prominence on the elytra.

The specimen from Portuguese East Africa is in poor condition and immature, but it appears to be referable to the present species.

#### Genus **Hodurus**, nov.

*Rostrum* continuous with the head and at its base not broader than the forehead, the apex rather deeply emarginate and without any clearly defined epistome; the scrobes broadly dilated behind, the lower margin rapidly curving downwards, the upper margin terminating rather abruptly in a bare callus at some distance in front of the eye; the mandibles densely setose, with a sharp median tooth and a large scar; the mentum large and without any setae. *Antennae* with the scape (in the position of rest) passing below the eye and exceeding its hind margin. *Prothorax* with distinct postocular vibrissae. *Elytra* without any humeral callus, the base not marginate, the lateral margin shallowly sinuate near the base. *Wings* not functional. *Sternum*: the prosternum almost as short behind as in front of the coxae, the front margin scarcely sinuate; the mesepimera small, so that the mesepisterna are broadly in contact with the elytra; the metasternum between the coxae much shorter than the median coxae and with a strong antecoxal fold, the hind coxae reaching the elytra. *Venter* with the intercoxal process broadly truncate, but narrower than the coxae; ventrite 2 (4) shorter than the next two ventrites together; anal ventrite of ♀ with a short longitudinal impression on each side near the base. *Legs* with the femora moderately clavate, the front pair not larger than the others; the tibiae only feebly denticulate internally, the corbels of the hind pair not enclosed, bare and only very shortly ascending the dorsal edge; the tarsi broad, spongy beneath, the claws free.



Genotype, *Hodurus dispar*, sp. n.

In Lacordaire's key, this species runs down to the Palaearctic genus *Amomphus*, Schh., in which, however, the rostrum is separated by a furrow from the head, the scrobes are narrow and parallel-sided, the front coxae are much closer to the anterior margin of the sternum, etc. Of the African TANYMECINI with free tarsal claws, the nearest allies of this genus are the wingless species of *Tanymecus*, which differ, *inter alia*, in having the mentum setose, the metasternum as long as the median coxae, the intercoxal process of the venter narrower and ogival, and ventrite 2 (4) as long as the next two ventrites together.

***Hodurus dispar*, sp. n. (text-fig. 2).**

♂♀. Integument black, with dense brown scaling above and grey beneath; the pronotum usually with a narrow median grey stripe and sparse grey scaling laterally; the scutellum grey or white; the elytra sometimes densely and indefinitely mottled with grey.



Fig. 2. *Hodurus dispar*, gen. et sp. n., ♂ (right), ♀ (left).

♂. *Head* with coarse, longitudinally confluent punctation, and with a median furrow that is continuous with that of the rostrum and extends shallowly to the vertex; the setae dark, stout and suberect; the eyes a little longer than broad, and rather strongly convex. *Rostrum* about as long as broad, almost parallel-sided, the genae only slightly widened; the dorsum longitudinally rugulose, with an irregular carina on each side (the two converging slightly towards the base) and a broad median impression containing a very broad and deep furrow from the base to the antennae; the apical area gently declivous and only shallowly impressed. *Antennae* with the scape compressed, gradually widening from base to apex, densely squamose, and with stout subrecumbent setae; the joints of the funicle in order of length: 1, 2, 3 (4, 7), 5, 6; 1 twice as long as 2, and the joints longer than broad; the club narrowly elongate. *Prothorax* as long as broad, gently rounded at the sides, widest before the middle, feebly constricted at the apex, truncate at base and apex, the former marginate; the dorsum slightly convex longitudinally, rugosely punctate, and with a very shallow and indistinct median furrow; the scales almost circular, fluted and overlapping, filling the punctures but not completely covering the raised parts; the setae brown or blackish, dense and subrecumbent. *Elytra* narrowly elongate, subparallel-sided from near the base to the middle, thence gradually narrowed to the apices, which are separately produced into a short process, without any preapical constriction or callus on the declivity, and the base shallowly sinuate; the dorsum

gently convex longitudinally, with broad, deep and slightly sinuate striae, containing punctures that are large and subquadrate near the base but rapidly diminish behind, being almost hidden by the scaling towards the apex ; the intervals not broader than the striae and with dense stout subrecumbent setae, the alternate ones more raised, rather broader and with more numerous setae. *Underside* clothed (in addition to the scales) with very dense long stout subrecumbent setae on the median area of the sternum and on most of the venter ; the two basal ventrites and the apical half of the anal ventrite with a broad median depression.

*Length*, 10.8-12 mm. ; *breadth*, 3.6-3.9 mm.

♀. Larger and much broader than ♂, and differing also as follows : *Rostrum* proportionately rather broader, with the same median sulcus, but without the median depression. *Prothorax* more rounded at the sides and a little broader than long. *Elytra* much broader, rounded at the sides ; the apical processes a little longer, usually divergent but sometimes contiguous ; the intervals broader, the alternate ones not or only slightly more raised. *Underside* with normal short sparse setae, the venter without the median depressions.

*Length*, 11.4-14.4 mm. ; *breadth*, 4.8-5.7 mm.

ORANGE FREE STATE : Valsch River, Bethlehem District, 15.xi.1920, 2 ♂♂, 4 ♀♀ (J. F. Heyman).

Reported by the Division of Entomology, Pretoria, as damaging maize.

***Ellimenistes echinatus*, sp. n. (Pl. xix, fig. 14).**

♂♀. Integument black, with uniform pale sandy brown or sandy grey scaling above, and chalky grey beneath.

*Head* even, set with not very dense erect scales, the interspaces more or less filled up with a grey earthy substance, and with two or three erect flattened setae above the eyes ; the latter not prominent and only slightly convex. *Rostrum* longer than broad and longer than the head, almost parallel-sided, being but very little widened at the apex, the interscrobial space as broad as the antennal scape ; the dorsum even, being set with densely packed erect scales, but leaving a narrow stria between the scrobes ; the sides and lower surface with rounded overlapping recumbent scales. *Antennae* with the scape extending to two-thirds of the prothorax, moderately curved, slightly clavate, with dense overlapping scales and stout subrecumbent setae ; the joints of the funicle in order of length : 2, 1, 3, 4, 5 (6, 7) ; 1 as long as 3 and 4, 7 a little longer than broad. *Prothorax* nearly twice as broad as long, widest at the base, narrowing to the apex, with the sides almost straight ; the base feebly arcuate, the apex slightly sinuate ; the dorsal outline almost flat and sloping from base to apex, the surface even, being clothed like the head with erect scales matted with an earthy substance ; the front margin with a projecting fringe of broader recumbent overlapping scales and with a group of two or three erect setae on each side of the middle line. *Elytra* ovate, widest before the middle, obtusely acuminate behind, shallowly sinuate at the base, and without prominences of any kind ; the dorsal outline moderately convex and deepest at about the middle ; the striae sharply defined and the punctures visible through the scaling ; the intervals broad and slightly convex, each with a single row of very long sharply-pointed erect pale setae ; the scales recumbent, densely overlapping and fluted. *Legs* black, with dense grey scaling ; external apical angle of front tibiae not produced.

*Length*, 3.3-4.5 mm. ; *breadth*, 1.8-2.7 mm.

TRANSVAAL : Nelspruit, 4.ii.1920.

Described from 16 specimens.

Reported by the Division of Entomology, Pretoria, as feeding on young shoots of lemon trees and damaging seedlings.

Most nearly allied to *E. setulosus*, Fhs. (1871), which differs in having the scaling on the head and pronotum recumbent; the eyes distinctly convex; the elytra steeply declivous at the base, and broadly rounded behind, the setae about half as long, dark and truncate, or bifurcate at the apex, the punctures not visible through the scaling; the external apical angle of the front tibiae is strongly produced, etc.

***Ellimenistes horridus*, sp. n.**

♂♀. Integument black, with dense brown scaling, often very indefinitely variegated on the elytra with grey scales.

Very closely allied to *E. echinatus*, sp. n., but slightly larger and with rather more globose elytra, and differing also from that species in the following characters: *Head* with the eyes as prominent as in *E. setulosus*, Fhs. *Rostrum* distinctly longer and narrower, narrowed from the base to the middle and only slightly dilated at the apex. *Prothorax* similarly clothed with matted erect scales, but more pulvinate on the basal half of the disk, and the erect setae stouter. *Elytra* broader and deeply sinuate at the base; the dorsal outline more convex, being much steeper at the base and perpendicular at the apex; the setae shorter (but not so short as in *E. setulosus*), stout and sharply pointed. *Legs* with the setae on the tibiae more conspicuous, being much broader and more raised; the front tibiae with the external apical angle distinctly produced.

*Length*, 3.6–4.5 mm.; *breadth*, 2.25–2.9 mm.

PORTUGUESE E. AFRICA: Tenga, 3 ♂♂, 2 ♀♀, on cotton, 21.iii.1924 (C. B. Hardenberg).

*E. setulosus*, Fhs., differs in having the scaling recumbent on the head and pronotum; the rostrum is much shorter and broader and more dilated at the apex; the prothorax is nearly parallel-sided behind, and distinctly constricted and transversely impressed near the apex; the form of the elytra is very similar, but the setae are much shorter and not pointed.

***Dicasticus mlanjensis*, sp. n.**

♂♀. Integument black or piceous, unevenly clothed with pale yellowish scaling having a slight brassy reflection, more or less variegated with pale metallic green scales on the disk of the pronotum and elytra.

*Head* not constricted behind the eyes, with only a very shallow impression between the forehead and the vertex; the forehead with a broad deep median sulcus densely squamose and with short scale-like subrecumbent setae; the scales on the vertex but little narrower than those on the forehead; the eyes comparatively only slightly convex. *Rostrum* about as long as broad, gradually widening from base to apex; the dorsal area laterally excised by the scrobes, shallowly impressed in the middle and with a low median carina. *Antennae* with the scape densely clothed with narrow yellowish (rarely greenish) scales and green at the apex, the setae long, stout and subrecumbent; the funicle always with pale blue-green scales, the joints in order of length: 1, 2, 3, 4, 7 (5, 6). *Prothorax* transverse, gently rounded at the sides, widest at the middle, shallowly constricted near the apex, truncate at the base, the apex broadly sinuate dorsally; the dorsum transversely convex, with a very shallow rounded impression on each side behind the middle and numerous scattered transverse shiny granules, each bearing a very short scale-like recumbent seta. *Elytra* broadly ovate in ♀, narrower in ♂, broadest before the middle and obtusely acuminate behind, without any trace of apical or subapical calli; the shallow striae much more regular and distinct than usual, and mostly with a bare patch between the large punctures, but these patches are elevated into definite small transverse rounded tubercles only on the basal third of stria 1; intervals 2, 4 and 6 much broader than the others, and



with irregular large punctures and bare patches ; the setae very inconspicuous, short, scale-like and recumbent on the disk, but a little longer and more noticeable on the declivity. *Legs* piceous or red-brown, rather thinly clothed with yellowish scales and subrecumbent scale-like setae ; the tarsi with blue-green scales.

*Length*, 7.8–12.0 mm. ; *breadth*, 3.6–5.7 mm.

NYASALAND : Mt. Mlanje, 58 ♂♂, 75 ♀♀, i.–ii.1913 (S. A. Neave), 1 ♂, 3 ♀♀, 2,000 ft., iii.–vi.1926 (C. Smee). PORTUGUESE E. AFRICA : Kola R., near Mt. Chipere, 1,500–2,000 ft., 2 ♂♂, 7.iv.1913 (S. A. Neave).

Mr. Smee, Government Entomologist, Nyasaland, reports that this weevil damages the leaves of tea bushes.

Allied to *D. funicularis*, Chev. 1881, and *D. gerstaeckeri*, Fst. 1893, which both differ, *inter alia*, in the following points : the eyes are much more convex ; the pronotum is flattened in the middle ; the striae on the elytra are much less distinct, the alternate intervals are not broader, and calli are present at and near the apices of the elytra.

#### Subfamily TANYRRHYNCHINAE.

##### Genus *Holorygma*, nov.

*Head* with the eyes sublateral and flattened, the forehead much broader than the interantennal space, but narrower than the rostrum. *Rostrum* elongate, continuous with the forehead ; the scrobes sublateral but entirely visible from above, running straight from the antennae to the eyes and produced beyond the antennae as a fine distinct stria to the extreme apex ; the apical margin truncate and without any clearly defined epistome ; the mandibles rather slender, with the inner edge simple, the pointed apex strongly incurved, a rather prominent transverse ridge on the external face near the base and two long setae behind it ; the lower surface with two distinct and rather closely approximated longitudinal striae ; the mentum filling the buccal cavity and bearing two suberect setae. *Antennae* inserted a little behind the middle, with the scape elongate, curved, clavate and extending beyond the eye ; the funicle with joint 1 longer than 2. *Prothorax* transverse, subtruncate or gently arcuate at the base, with feeble postocular lobes. *Elytra* subglobose, shallowly punctate striate, and subtruncate at the base. *Legs* with the hind coxae not reaching the elytra ; the femora simply clavate ; the tibiae not denticulate internally, all with a pad of soft hairs at the inner apical angle, the posterior pairs somewhat dilated externally and internally at the apex, the front pair not produced externally, the hind corbels enclosed ; the tarsi with joint 2 transverse and a little narrower than 1, 3 as long as and broader than 1, the claws small and connate at the base. *Sternum* with the gular margin deeply sinuate, the metepisternal suture obsolete. *Venter* with ventrite 2 (4) shorter than the next two together.

Genotype *Holorygma pilosa*, sp. n.

The insect for which this genus is proposed is most nearly allied to *Zeugorygma*, Mshl. 1906, the species of which it much resembles in general facies, including the long erect setae on the elytra. But in *Zeugorygma* the rostral structure is very different, the scrobes being ante-median, foveiform and very close together, so that the interspace is narrower than the basal part of the antennal scape ; the second joint of the funicle is longer than the first ; and ventrite 2 (4) is as long as the next two together.

***Holorygma pilosa***, sp. n. (Pl. xix, fig. 10).

♀. Integument brown, with uniform arenaceous scaling. All the specimens have the entire upper surface covered with a dense earthy coating, through which the setae project.



*Head* with a fringe of erect scales and two erect setae on each side of the forehead, the eyes quite flat. *Rostrum* as long as the head and prothorax, parallel-sided in the middle and slightly widened at the base and apex, with the dorsal outline obtusely subangulate at the insertion of the antennae and the lower surface gently curved; the dorsal interscrobial area parallel-sided from the base to the antennae, flat and covered with dense erect scales and short suberect setae, the anterior portion gradually widening to the apex and covered with flat round scales; the compressed lower surface more or less densely clothed with round scales having a slight metallic reflection. *Antennae* with the scape slightly exceeding the front margin of the thorax, curved, densely squamose, and with a few short recumbent setae; joints of funicle in order of length: 1, 2, 3, 4, 6, 7, 5, and all longer than broad. *Prothorax* transverse (3:2), rounded at the sides, widest near the base, broadly and shallowly constricted at the apex, the constriction being continued across the dorsum, and the dorsal apical margin gently arcuate; the dorsum even and without any median sulcus or carina, the erect setae much shorter than those on the elytra, there being usually four along the front margin, a pair on each side before the middle and a few on the disk. *Elytra* widest a little before the middle, broadly rounded behind, with the dorsal profile moderately convex, highest at about the middle, the declivity being long and very steep; the feeble striae discernible through the scaling, but with their punctures almost obsolete; the intervals broad and almost flat, with overlapping scales, and each with a row of long stout erect pointed setae. *Legs* densely squamose and with short scale-like recumbent setae.

*Length*, 2.4-3.0 mm.; *breadth*, 1.6-2.1 mm.

TRANSVAAL: Nelspruit, 5 ♀♀, 4.ii.1920.

Reported by the Division of Entomology, Pretoria, as damaging lemon seedlings and feeding on the young shoots.

**Goniorrhinus hardenbergi**, sp. n. (Pl. xix, figs. 5).

♂♀. Integument black or piceous, with dense pale greyish-green scaling above and below; the pronotum with two ill-defined broad brownish stripes, nearly contiguous on the front margin and widening and diverging posteriorly to the hind margin; the elytra with intervals 2-4 more or less brownish from the base to the declivity.

*Head* so much narrowed in front that the eyes appear to be almost on the base of the rostrum, the space between them being much narrower than the club of the scape, but broader than its basal width; the eyes almost flat, and (when viewed laterally) their upper edge is on a level with the dorsal outline of the rostrum. *Rostrum* as long as the head and pronotum, moderately stout, parallel-sided, with the dorsal outline angulated at the insertion of the antennae (at about the middle) and the ventral outline concave; the scrobes entirely dorsal, ovate and about as long as the club of the scape, the interscrobial space approximately as wide as the forehead, and the outer edge of the scrobe continued backwards to the base in the form of a subcarinate margin to the dorsal area; the dorsum in the basal half covered with dense scaling and curved squamiform setae, the median area flattened and narrowing in front (sometimes with a fine median carina), the lateral areas sloping outwards, also flattened, but parallel-sided from the eye to the scrobe; the apical half with sparse scales and setae, and with an obtuse median carina that widens in front and a shallow furrow on each side; the lower surface bare, and with fine separated punctures. *Antennae* with the scape just reaching the front margin of the prothorax, quite straight and rather abruptly clavate; the funicle with joint 1=2+3, 3 longer than 4, 4=5, 6 and 7 subequal and a little shorter, all longer than broad. *Prothorax* a little longer than half the basal width, widest at the base and rapidly narrowed in front, slightly rounded at the sides and shallowly constricted at the apex; the apical margin truncate, the

base strongly arcuate ; the dorsum gently convex longitudinally and sloping forwards, quite even, the close shallow punctures being hidden by the rounded contiguous scales ; the setae squamiform, recumbent and very inconspicuous. *Elytra* globose, the sides forming almost a continuous line with those of the prothorax, widest much before the middle, deeply sinuate at the base and broadly rounded behind (as seen from above) ; the dorsal outline moderately convex, highest behind the middle, the posterior declivity perpendicular or slightly retuse at the apex ; the punctures in the shallow striae not entirely hidden by the scaling, becoming smaller behind ; the intervals broad and almost flat, with numerous irregular subrecumbent scale-like setae ; the scales subcircular, contiguous and convex. *Legs* with dense pale green and grey scaling, and with recumbent scale-like setae on the femora, which are stout ; the tibiae widening at the apex ; the tarsal claws connate.

*Length*, 3.3-3.6 mm. ; *breadth*, 1.8-2.25 mm.

PORTUGUESE E. AFRICA : Moamba, 1 ♂, 3 ♀♀, on cotton, 27.iii.1924 (*C. B. Hardenberg*—type) ; Umbelusi, 1 ♂, 1 ♀, 24.iii.1921 (*Hardenberg*).

The only other known species of the genus, *G. erinaceus*, Fst. 1889, differs in having very long erect setae on the elytra ; the scape of the antennae exceeds the front margin of the prothorax, and the two basal joints of the funicle are equal ; and the base of the prothorax is only feebly rounded.

#### Subfamily GONIPTERINAE.

#### *Gonipterus gibberus*, Boisd.

Dr. C. A. Marelli has recently described (Mem. Minist. Obras Publicas. Prov. Buenos Aires, 1924-25 (1926), pp. 597-646, 2 figs., 3 pls.) two species of weevils attacking eucalyptus in Argentina. For these he made a new genus *Dacnirotatus*, the two species being *D. bruchi* and *D. platensis*. Dr. Marelli has now very kindly submitted to me a long series of adults and larvae, and these show that *D. bruchi* is synonymous with the Australian *Gonipterus gibberus*, Boisd., whereas *D. platensis* is based on immature specimens of the same species.

#### *Chalcodermus bondari*, sp. n.

♂. Colour rather shiny black, with hardly a trace of bronze on the elytra.

*Head* opaque, finely shagreened, with scattered shallow punctures, and the space between the eyes broader than the apex of the scape. *Rostrum* slightly curved, not elevated in the middle of the base, finely aciculate and coarsely punctate at the sides in the basal half, with four irregular rows of punctures dorsally, leaving a smooth median line from the base almost to the apex. *Antennae* piceous, the funicle with joint 1 as long as 2+3, 3 and 4 longer than broad, 5 and 6 nearly as broad as long, and 7 slightly transverse. *Prothorax* transverse (11 : 8), almost parallel-sided from the base to beyond the middle and abruptly narrowed in front, the basal angles right angles, the base shallowly bisinuate, and the apex not produced dorsally ; the dorsum moderately convex longitudinally and highest behind the middle, with three transverse furrows in the middle, which laterally curve forwards and become branched, forming five or six oblique furrows on each side and all curving round to the apex ; in the middle of the apical half six, sometimes irregular and interrupted, longitudinal furrows ; the raised areas costate, convex and shiny, with sparse short pale recumbent setae on the edges of the sulci. *Elytra* broadly ovate, with the shoulders obliquely curved and only very slightly projecting laterally, subparallel-sided from there to beyond the middle, then arcuately narrowing to the apices, which are jointly rounded ; the dorsum scarcely sulcate on the disk (and only shallowly so at the sides and apex), and with regular rows of foveae, which become smaller behind ; the septa between the foveae about as broad and as high as the intervals between the rows, the intervals almost glabrous on the disk, but finely aciculate towards the base, sides and apex,

and with sparse irregular minute pale recumbent setae. *Legs* very shallowly punctate and with pale recumbent setae; the tibiae bisinuate on the inner edge and without any sharp tooth or serration.

*Length*, 3.6 mm.; *breadth*, 1.8 mm.

BRAZIL: Bahia, 2 ♂♂, 1925 (*Dr. G. Bondar*).

*Dr. Bondar* reports that this weevil is quite a significant pest of cotton, the larvae living in the flower-buds.

From all the species of *Chalcodermus* in which the thorax is plicate (except *C. plicaticollis*, Fhs. 1837, and *C. longirostris*, Fhs. 1837) *C. bondari* differs in its simply bisinuate tibiae, and from all except *C. longirostris* in not having the elytra subtriangular. The latter Central American species is its nearest ally, and differs as follows: The sides of the prothorax are more rounded, and not parallel, the furrows are broader and finely aciculate, and the longitudinal outline is more convex and highest in the middle; the elytra are subsulcate and the intervals distinctly costate.

Nothing is known as to the habits of *C. longirostris*, but its close relationship to *C. bondari* suggests that it may also be a potential cotton pest. *Champion* records it from various localities in Mexico, Guatemala, Panama and British Honduras, and states that it is there apparently the commonest species of the genus.

#### Subfamily BARIDINAE.

#### Genus *Lophobaris*, nov.

*Rostrum* arched at the base, and separated from the head by a broad transverse impression, laterally compressed at the base, and dorso-ventrally compressed at the apex, and with the antennal insertion beyond the middle; the mandibles obtusely toothed and interlocking. *Antennae* with the scape not quite reaching the eye; the funicle gradually widening apically, joint 7 not annexed to the club, the basal joint of which is pubescent like the rest. *Elytra* much broader than the prothorax, ovate, squamose, with the humeral angles and the posterior calli prominent. *Wings* functional. *Legs* with the femora scarcely clavate, but distinctly curved in the apical half and not sulcate beneath, the front pair with 3 or 4 short sharp teeth on the lower face, the posterior pairs with 1 or 2; the tibiae with a strong angulation dorsally near the base, otherwise straight and sulcate; the tarsi with the two basal joints of equal width, joint 2 transverse, joint 3 much wider, the claws free. *Sternum* with a shallow prosternal furrow, the space between the front coxae as broad as a coxa, the spaces between the posterior pairs of coxae being broader than their respective coxae; the mesosternum transversely impressed at the base. *Venter* with the incision between ventrites 1 (3) and 2 (4) strongly arched, the latter ventrite as long in the middle as the next two together; the pygidium short, strongly transverse, quite invisible from above, and with its upper edge sharply delimited by a transverse carina which engages with the apex of the elytra.

*Genotype*, *Lophobaris serratipes*, sp. n.

On account of its impressed mesosternum this genus belongs to the "*Baridiides vrais*" of *Lacordaire* and comes nearest to *Baris*, from which it differs in its sulcate prosternum, in the form and position of the pygidium, the denticulate femora, the basally angulate tibiae, etc.

#### *Lophobaris serratipes*, sp. n. (Pl. xix, fig. 12).

♂♀. Integument dull black, variegated with blackish and fulvous scales, which here and there form erect tufts; the head with fairly dense subrecumbent fulvous scales; the rostrum with a tuft of erect fulvous scales at the base; the pronotum with scattered fulvous scales, and usually in the basal half a median fulvous stripe and an indefinite oblique one on each side, two mainly black tufts on the apical margin



and a transverse row of three more in front of the middle ; the elytra with the fulvous scales principally along the sutural area and in low tufts near the lateral margin, a very large tuft of black scales at the apex of interval 5 and the following smaller tufts of mingled black and fulvous scales : one before and another behind the middle on int. 2, near the base of int. 3, about the middle of int. 5, behind the middle on int. 7, on the shoulder, and before the middle and at the apex of int. 9 ; the sternum with sparse narrow pale scales, those on the venter much smaller and setiform.

*Head* rugosely and confluent punctate, but the sculpture hidden by the scaling. *Rostrum* of ♂ about as long as the pronotum, with coarse, longitudinally confluent punctation throughout forming irregular shallow furrows, and with a narrow median carina from the base to the antennae and a less distinct one on each side of it ; that of ♀ slightly longer, with fine separated punctures in the apical half and the carinae much less distinct. *Antennae* with joint 1 of the funicle a little longer than 2+3, joint 2 a little longer than broad, 3 slightly transverse, and the remainder progressively more transverse, 7 being twice as broad as long. *Prothorax* slightly broader than long, parallel-sided from the base nearly to the middle, then roundly narrowed to the abruptly tubular apex ; the apical margin somewhat produced dorsally and with feeble postocular lobes, the base strongly bisinuate ; the dorsum with large deep separated punctures, the interspaces being finely shagreened and about as wide as the punctures, and before the middle a large obtuse median elevation which bears the median tuft of the transverse row ; the scales in the tufts longer and narrower than the recumbent ones. *Scutellum* small, trapezoidal, bare and slightly impressed. *Elytra* ovate, widest behind the shoulders, broadly rounded behind, highest at about one-fourth from the base and gradually sloping to the apex ; the striae deep, not straight but more or less sinuous, and containing shallow indefinite punctures ; the intervals broader than the striae, quite flat, dilated where the tufts of scales occur, and when abraded these areas are shiny and set with strong separated punctures, whereas the remaining surface is finely aciculate and opaque, the juxta-sutural intervals being transversely rugose near the base. *Legs* blackish, the tarsi piceous ; the femora very rugosely punctate and with subrecumbent fulvous scales.

*Length*, 3.9–4.8 mm. ; *breadth*, 1.8–2.4 mm.

JAVA : Salatiga, 1915 (*Dr. Roepke*—type). MALAY PENINSULA : Ginting Sem-pak, Selangor, 5.viii.1922 (*H. M. Pendlebury*).

Described from 15 specimens.

The Java examples were bred from pepper seeds.

#### Genus *Omobaris*, nov.

*Head* separated from the rostrum by a very feeble impression. *Rostrum* stout and curved, slightly compressed basally and but little narrowed dorso-ventrally at apex ; the scobes rapidly passing beneath the rostrum ; the mandibles strongly bidentate and decussate ; the apex of the submentum produced into a short, sharp, downwardly directed process, in the ♂ only. *Antennae* with the scape not quite reaching the eye ; the funicle gradually widening outwardly, joint 7 fitting rather closely to the club ; the club broadly ovate, joint 1 about as long as the remainder and thinly pubescent. *Prothorax* parallel-sided in the basal half, bisinuate at the base, truncate dorsally and laterally at the apex. *Elytra* subtriangular, widest at the shoulders, which are very prominent and almost rectangular, the width at the shoulders being  $1\frac{1}{2}$  times the width of the prothorax, with 10 striae, the tenth being complete and distinct. *Legs* with the femora moderately clavate, not sulcate or toothed beneath, but with a row of small sharp granules on the lower surface ; the tibiae bent at the base, otherwise straight, uncinatate at the apex, and with the outer apical angle not produced ; the tarsi rather thinly pubescent beneath, joint 3 deeply bilobate, 4 comparatively short, the claws small and free. *Sternum* : the front margin of the prosternum deeply



sinuate, the hind margin truncate, the intercoxal space three-fourths the width of a coxa, the antecoxal area very shallowly depressed; the mesosternum depressed. *Venter* with the pygidium invisible from above and only a short piece visible from beneath in both sexes; ventrites 3 and 4 (5 and 6) as long as 2 (4) and each with a single regular transverse row of punctures.

Genotype *Omobaris calanthes*, sp. n.

The very prominent shoulders combined with the basally parallel-sided prothorax give a very distinctive appearance to the species for which this genus is proposed. In other respects it seems to come nearest to the genus *Baris*, from typical members of which it differs also in its almost concealed pygidium, the punctuation of the intermediate ventrites, and the apically undilated tibiae.

Dr. K. M. Heller has kindly examined both this and the preceding species and informs me that they do not belong to any of the Oriental genera of Barids described by Faust.

***Omobaris calanthes*, sp. n.**

♂ ♀. Colour shiny black or piceous, entirely devoid of scaling, with the antennae and tarsi paler.

*Head* finely aciculate and with scattered shallow punctures. *Rostrum* as long as the head and prothorax, not dilated at the apex, rather strongly curved, not so thick as the front femora, with irregular rows of close punctures dorsally (slightly coarser in ♂) leaving an impunctate median stripe from about the middle to the apex; the sides aciculate and with shallow confluent punctuation. *Antennae* testaceous brown; joint 1 of the funicle a little longer than the next two together, joints 2-7 transverse. *Prothorax* nearly as long as broad, parallel-sided from the base to the middle, thence roundly narrowed anteriorly and shallowly constricted near the apex, which is two-thirds the width of the base; the dorsum longitudinally convex, highest in the middle, and closely set with strong deep punctures, without any smooth median line; the interspaces much narrower than the punctures, which are obliquely sub-confluent on the posterior half of the disk; the pleurae more opaque than the disk and with the punctures rather larger; each puncture with an extremely minute horizontal seta. *Scutellum* ovate, aciculate. *Elytra* subtriangular, with the sides shallowly sinuate behind the very prominent shoulders, then gradually narrowing in a curve to the apex, with the posterior calli feeble and the apices jointly rounded; the striae narrow and deep, containing shallow distant punctures that slightly indent the margins of the striae, except at the apex of stria 10 where there are 6-8 larger and closely placed punctures, only striae 3-6 actually reaching the base; the intervals much broader than the striae, flat, smooth and shiny, each with a single row of very minute distant punctures. *Legs* with the femora coarsely punctate, each puncture containing a short, pale recumbent seta; the tibiae opaque, with very shallow indistinct punctures and feeble carinae. *Underside* with coarse setigerous punctures, which are more sparse on the venter than on the sternum.

*Length*, 2.7-3.0 mm.; *breadth*, 1.2-1.8 mm.

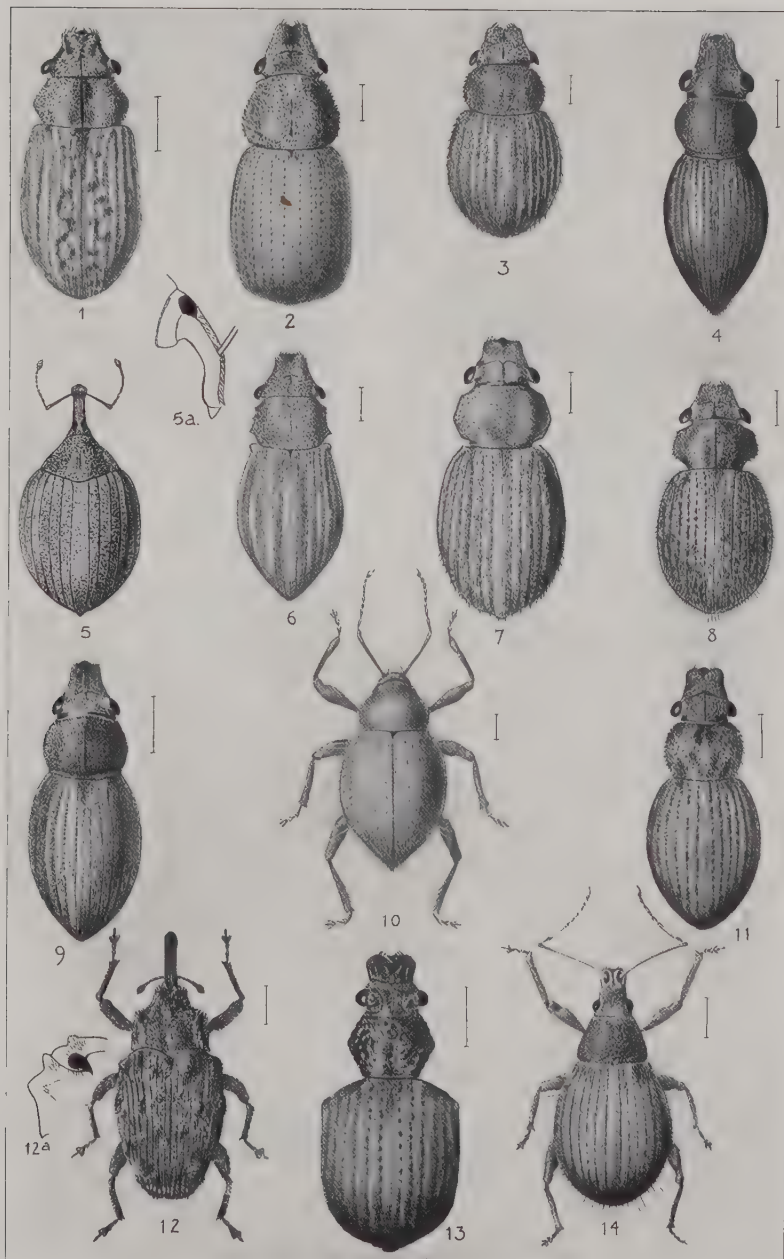
JAVA: Buitenzorg, 4 ♂♂, 3 ♀♀, 28.ix.1926 (*H. Wigman*).

Received from Mr. S. Leefmans, who states that the adult weevils damage the leaves of an orchid, *Calanthe veratrifolium*.



# EXPLANATION OF PLATE XIX.

- Fig. 1. *Protostrophus gonoderes*, sp. n., p. 201.  
 „ 2. „ *oblongus*, sp. n., p. 202.  
 „ 3. „ *gulo*, sp. n., p. 203.  
 „ 4. „ *vastator*, sp. n., ♂, p. 207.  
 „ 5. *Goniorrhinus hardenbergi*, sp. n. ; a, side view of head and rostrum ; p. 214.  
 „ 6. *Protostrophus ocularius*, sp. n., p. 204.  
 „ 7. „ *gonocnemis*, sp. n., p. 205.  
 „ 8. „ *crinitus*, sp. n., p. 206.  
 „ 9. „ *vastator*, sp. n., ♀, p. 207.  
 „ 10. *Holorygma pilosa*, gen. et sp. n., p. 213.  
 „ 11. *Protostrophus latirostris*, sp. n., p. 208.  
 „ 12. *Lophobaris serratipes*, gen. et sp. n.; a, side view of head and pronotum ;  
     p. 216.  
 „ 13. *Blosyrus batatae*, sp. n., p. 199.  
 „ 14. *Ellimenistes echinatus*, sp. n., p. 211.



New Injurious Curculionidæ.





THE HABITS OF *ALYSIA MANDUCATOR* (HYM., BRACONIDAE).

By J. G. MYERS, Sc.D.

Imperial Bureau of Entomology.

**1. Introduction.**

The observations here recorded were made during the rearing of *Alysia manducator*, Panz., as a parasite for Australasian sheep-maggots by the Imperial Bureau of Entomology, and are published by permission of the Director, Dr. G. A. K. Marshall. They form merely a supplement to the accounts of this species included in two excellent papers by G. S. Graham-Smith (1916, 1919), and one equally thorough by G. M. Altson (1920).

The present studies were carried out in North Essex during August-November, 1926. I am very much indebted to Mr. B. Golding and Miss Golding, for giving me all possible facilities for working at Street Farm, Ashen; and to my wife for keeping the time during the heart-beat observations.

*Alysia manducator* is a blackish, rather stoutly-built Braconid about a quarter of an inch in length. The female lays usually one egg in a Muscid maggot of considerable size. Very little further development appears to take place until the maggot pupates, when the *Alysia* larva rapidly consumes it and accomplishes its own metamorphosis within a silken cocoon with which it lines the puparium. The adult Braconid emerges a few weeks later at the anterior end of the puparium; but eggs deposited in autumn do not complete their cycle until the following year, when about a third of the imagines appear in spring and two-thirds in the following autumn (Graham-Smith). No hyperparasites are known, but Graham-Smith has recorded destructive superparasitism by *Melittobia acasta*, Walk. (1916, pp. 533-535), and by *Mormoniella* (*Nasonia*) *brevicornis*, Ashm. (1919, p. 378). Altson (1920) has shown that buried puparia are normally beyond the reach of *Mormoniella*, which is not adapted for burrowing.

**2. Factors influencing Oviposition.**

When rearing or attempting to rear *Alysia manducator* in large numbers, one is soon impressed by the tremendous variation in the rate of parasitism among maggots from different baits, all exposed in the same district and at the same season. General experience would suggest three factors as influencing this disparity: (a) the situation of the bait; (b) the nature of the bait; and (c) the identity of the maggots feeding upon it.

*Situation of the Bait.*

*Alysia* was observed ovipositing in considerable numbers in both the most sunlit situations and the most shady places in which, during the present work, the baits were exposed. The energetic females even crowded through an inch-wide opening into an iron boiler hidden in a shaded ditch-bottom. It is therefore considered that not much importance is to be attached to the *direct* influence of this factor, especially since, on occasion, a parasitism rate of nearly 100 per cent. was obtained both in a fairly sunny situation (a hanging tin) and in one exceedingly shaded (an enclosed hutch in a ditch-bottom).

*Nature of the Bait.*

Graham-Smith (1919, p. 381) has shown that *Alysia* does not attack larvae living in faecal matter. In the present work even visceral offal used as the sole

constituent of a bait was found to produce very few parasitised puparia, but whether this failure and that of faecal material were due directly to the medium or to the species of maggots preponderating in it remains unproven. It was found, however, that small fresh carcasses form an ideal bait for *Alysia* and that the preference for these, as the next section will show, is probably due to a similar preference on the part of the flies of the genus *Lucilia*.

### *Identity of the Host-maggots.*

Unless one takes elaborate precautions in isolating and determining parasitised maggots and puparia, it is difficult to discover whether or not *Alysia* is restricted to specific hosts. A full list of hosts is not attempted here; but a consideration of our own and published records shows that while *Alysia* is by no means restricted in its choice, it has strong preferences.

Dalla Torre (Cat. Hymen., iv, 1898, p. 46, note 2) lists as hosts the Diptera, *Lucilia caesar*, L., *Muscina stabulans*, Fall., *Hydrotaea dentipes*, F., and the Coleopteron, *Creophilus maxillosus*, L. Altson (1920, p. 216) records the following Diptera, *Lucilia sericata*, Meig., *L. caesar*, L., *Phormia groenlandica*, Ztt., *Calliphora erythrocephala*, Meig., and *C. vomitoria*, L.

Graham-Smith found *Alysia* to oviposit in larvae of *Calliphora* and *Lucilia*. In our own experiments adults have been reared from puparia of three main types—the large puparia of the *Calliphora* type, the medium-sized ones of *Lucilia* and the often much smaller spiny puparia of the *Fannia* type; but considerably more often from moderately-sized puparia and especially those of *Lucilia* than from any others. The occurrence of successful parasitism in the *Fannia* puparia indicates a probability that *Alysia* will attack the spinous maggots of *Chrysomyia rufifacies*, Macq., one of the Australian sheep-maggot flies which is now established in New Zealand.

Even if we exclude the single beetle record as almost certainly an accidental case, the list of hosts of *Alysia manducator* is thus, so far as we know, taxonomically fairly extensive. But all these larvae inhabit decomposing carcasses, and at various ages would offer a target of similar size to the ovipositor of *Alysia*. From the experimental work there is thus every justification for supposing that *Alysia* confines itself to carcass-feeding maggots; and no grounds exist for the fears which have been expressed that *Alysia*, if introduced into new lands, might parasitise the larvae of beneficial Syrphid or Tachinid flies. Taxonomically the host-preferences of *Alysia manducator* are perhaps somewhat diverse; ethologically they are remarkably restricted.

Quantitative experiments show that the maggots of the foregoing species are parasitised with by no means equal readiness. Rates of parasitism were estimated in a number of cases. It may be first remarked that the overwhelming majority of larvae exploiting the fresh carcase of a small animal in North Essex belong to the genera *Calliphora* and *Lucilia*. Among lots of maggots consisting solely of the former, five escaped parasitism of *Alysia* altogether, while one showed 0·8 per cent. attacked. Batches of nearly pure *Lucilia* puparia produced *Alysia* at the rates of 80 and nearly 100 per cent., while mixed lots containing both *Lucilia* and *Calliphora* gave figures of 43, 54 and nearly 100 per cent. There is thus every indication that maggots of the *Lucilia* type are the favoured hosts of *Alysia manducator*.

But this season at least, in North Essex, the activity of *Lucilia* was almost over by the beginning of the last week in September, though one adult was seen on ivy flowers as late as 1st November; while *Calliphora* continued for at least another six weeks and was seen on ivy flowers in some numbers on 12th November and attracted to a carcase on 17th.

Thus in the late autumn *Alysia* is necessarily more or less restricted to maggots of *Calliphora* (chiefly *C. erythrocephala*, Meig.). I think that these are preferred to any others save *Lucilia*, and that the selection of maggots of these two genera as

first and second choice respectively is one which is made deliberately by the ovipositing Braconid. For example, six females of *Alysia* on 10th November (in a warm room) were given 71 maggots, of which 58 were *Calliphora*, mostly full-fed and 13 of another, smaller, slenderer and more yellowish species, which seemed to me to have a tougher and certainly less transparent integument. All the 58 bluebottle larvae were parasitised in turn, including three or four which, being only partly grown, were much smaller than the second kind, so that size was evidently not a factor. The 13 of the other species were finally left alone. Now and then an *Alysia* would attempt oviposition upon them, but never succeeded, though the victims seemed to struggle less rather than more violently than *Calliphora* maggots similarly attacked. The skin seemed tough enough to resist the ovipositor.

#### *Combined Factors.*

We are now in a position to estimate the combined influence of the factors concerned in the rate of parasitism. During summer and early autumn *Lucilia* maggots seem to be the favourite hosts, and *Lucilia*, as noticed also by Graham-Smith, is predominantly attracted to fresh carcases, especially those exuding blood and lying exposed in open situations. Bluebottles (chiefly *Calliphora erythrocephala*) are attracted to staler baits, and are much more assiduous in searching them out in deep shade or under cover. They also breed in intestinal matter much more than does *Lucilia*. The visceral material mentioned above was infested solely by *Calliphora* maggots, and this is believed to be the cause of the negligible rate of parasitism in these baits. The bait which is likely, then, to attract most individuals of *Alysia* is a small fresh carcase, preferably bleeding and exposed in the open. But when the season for *Lucilia* maggots is ended *Alysia* will oviposit freely in bluebottle larvae.

### **3. The Process of Oviposition.**

The female *Alysia* may be seen burrowing in and around carcases in which maggots are no more than a day old, or even not yet hatched. During August, activity may begin in the very early morning, but the cooler nights of autumn soon induce considerable torpidity.

This species is remarkable for the assiduity with which the female searches for suitable maggots, ovipositing in one after another until, as Graham-Smith has also noticed, its movements become slower and slower apparently from sheer fatigue. During the search, no filth is too entangling to be penetrated, and the wings of the Braconid are finally put completely out of action by the adhesion of decaying matter long before the ovaries are spent or the energy exhausted.

The actual process of oviposition has been described by Graham-Smith (1919, p. 379) and by Altson (1920, pp. 209-213), but I have been impelled to study it in greater detail. Oviposition may occur through the skin and hair of a small mammal or even through a wriggling layer of day-old maggots covering larger larvae. The Braconid is frequently observed walking over such a substratum as the latter, stabbing vigorously and repeatedly with short, sharp movements of the ovipositor. This appears to be purely a searching process; no oviposition has been seen in small maggots, and the above movements were even observed when the wasps were crawling on the carrion-soiled surface of a pill-box. Probably, the suitable bait, and perhaps a suitable part of it, are located from afar by an olfactory sense seated in the antennae—since, as remarked above, *Alysia* frequently arrives at a bait long before large enough maggots are present—while the individual prey is discovered by touch through the agency of the palp-like organs of the ovipositor-sheath. These latter are perhaps the “palp-like appendages” mentioned in the hive-bee by Imms (Textbook, 1925, p. 533, fig. 517, SP.). I cannot agree with Altson (1920, pp. 210, 212) that these organs locate the larvae by smell. The difficulties of such a view are almost insuperable. Corro-



borating evidence in large measure would surely be necessary to justify the postulation of a sense of smell so refined as to be capable of differentiating the individual odours of thousands of maggots squirming in a common mess of carrion. Secondly, we know of no other case in the Insecta where olfactory organs are situated on the abdominal appendages; and thirdly, it seems more probable that the organs in question should exercise a tactile function. Finally, Altson himself notes that motionless maggots are passed over by the ovipositing *Alysia*.

As regards the function of the antennae, the following experiment shows that they are not essential to oviposition when suitable maggots are at hand. A captured female, which had shown itself especially energetic in attacking large maggots, was engaged in this task one morning when I cut off both antennae as closely as possible. Small stumps of the scapes remained. After this operation its gait was rather peculiar, with head bowed close to the substratum. When maggots came in its way, however, its behaviour was much as before, but rather less efficient. And more often than many of its whole companions, it was thrown off by the struggles of the larva. In an hour it succeeded in ovipositing in five full-fed *Calliphora* maggots, but next day it was dead.

When a maggot of suitable size—usually a full-fed *Lucilia* or *Calliphora* larva—is encountered, the *Alysia* female adopts, where possible, a straddling position. The ovipositor is inserted usually near the anterior end of the victim, occasionally at the posterior end (sometimes full in the stigmatic area) and less frequently in the middle of the body. When the larva is in the open, a struggle invariably ensues, and the Braconid is often thrown completely off. But more often, though dashed from side to side and hurled over and over by the frantic writhings of the maggot, the *Alysia* retains its hold. There is astonishing individual variation in behaviour among females of the same age under similar conditions—an idiosyncrasy independent of the size of either host or wasp. Some are frenzied workers, succeeding in maintaining their hold nine times out of ten, and wearing themselves out in a few days, while others withdraw the ovipositor if the larva squirms too vigorously, and regularly fail to oviposit in nine out of every ten maggots tackled. Such individuals live considerably longer.

The extremely violent writhing of the larva is apparently evoked by the actual entrance of the ovipositor. It is stopped with remarkable suddenness, and the maggot lies inert, usually with the head somewhat retracted, for about half a minute, presumably while the Braconid lays an egg. Altson believes that this paralysis is induced by the injection of a poison. This seems a much more plausible theory than that of nerve paralysis by direct mechanical action, for the Braconid may sting at almost any point in the body of the maggot, and does not repeat the thrust elsewhere.

After the withdrawal of the ovipositor the victim continues motionless for a variable time longer (see following table) before suddenly beginning, usually with but little premonitory movement, to wriggle almost as violently as during the attack. Altson thinks that this struggling is an attempt to crush the introduced egg by muscular contraction. The wasp does not feed at the oviposition-puncture.

Before resuming activity the maggot is to all appearance dead; no handling evokes a response and *there is no perceptible beating of the heart*. This organ does not recommence beating until the violent struggles above-mentioned have been continued for some time. Then one which was timed from the first few perceptible beats (I am not certain of seeing the very first) gave 225 in two minutes, or an average of 112.5 a minute. The normal rate of heart-beat in similar full-fed *Calliphora* maggots under the same conditions, and from the same source, would appear to be 120.8 a minute (average of six, of similar size, which gave respectively 222, 238, 239, 248, 252 and 252 in two minutes). Even apart from these figures, observation seemed to show that the heart, in larvae parasitised as above, when it did recommence, did so at about the normal rate. A similar maggot from the same batch, placed in an

ordinary potassium cyanide killing-bottle for half an hour, gave a heart-beat rate of only 71 in two minutes, or 35.5 a minute. The action of the Braconid poison, if it be a poison, is thus radically different in that it stops the heart instantly and after a variable period allows its resumption at approximately the normal rate.

The periods of all the successive stages of oviposition and recovery are susceptible of great variation; and this variation is not all explained by the age or physical condition of the female Braconid, though this is doubtless a main factor. From Altson's records and my own observations it appears that not only do the females regain their strength after a period of rest, but the poison injected also has a stronger effect than at the end of a period of oviposition.

The preliminary struggles of the maggot after stunning are sometimes succeeded by further quiescence before the violent squirming begins in earnest. Usually the first part to show signs of returning animation is the head; at other times, but much less frequently, the posterior extremity. This does not seem to be dependent on the point of oviposition. In two cases, with a probably exhausted female, struggling occurred immediately after the Braconid left, and in one of these the maggot was at no time quite quiescent. In both, however, the heart had stopped beating. The following table shows the variation in length of the quiescent period after departure of the Braconid, and in duration of cessation of heart-beat from the same moment. The forty cases were observed under similar conditions in a warmed room, on the 11th, 12th, 13th and 15th November, using the same Braconid females and *Calliphora* maggots from the same bait.

From time <i>Alysia</i> left till first struggle.			From time <i>Alysia</i> left till first heart-beat.		
First day.					
1.	20	seconds.	2	minutes, 17	seconds.
2.	37	"	1	" 22	"
3.	26	"	2	" 24	"
4.	41	"	3	" 26	"
5.	53	"	2	" 44	"
6.	50	"	3	" 58	"
7.	not observed.		1	" 40	"
8.	"	"	2	" 12	"
Second day.					
9.	1	minute, 10 seconds.	5	" 40	"
10.		25 "		45	"
11.		20 "		45	"
12.		46 "	1	" 30	"
13.		15 "	2	" 30	"
14.		0 "	1	" 25	"
15.		8 "	1	" 25	"
16.		20 "	2	" 40	"
17.		20 "		50	"
18.		40 "	2	" 25	"
19.		30 "	2	" 35	"
20.		15 "	4	" 0	"
21.	2	" 0 "	3	" 35	"
22.	1	" 2 "	4	" 5	"
Third day.					
23.	1	" 20 "	8	" 46	"
24.		33 "	4	" 50	"
25.	1	" 50 "	7	" 12	"
26.	1	" 40 "	3	" 48	"
27.	1	" 6 "	11	" 58	"
28.		58 "	10	" 0	"
29.	1	" 27 "	14	" 16	"

From time <i>Alysia</i> left till first struggle.			From time <i>Alysia</i> left till first heart-beat.		
Fourth day.					
30.		15 seconds.	3 minutes, 0 seconds.		
31.	1 minute,	0 "	2 "	5 "	
32.	1 "	40 "	3 "	15 "	
33.	2 "	30 "	14 "	30 "	
34.	1 "	20 "	9 "	25 "	
35.	1 "	50 "	6 "	50 "	
36.		17 "	4 "	5 "	
37.	2 "	5 "	7 "	15 "	
38.	2 "	10 "	6 "	25 "	
39.	2 "	20 "	14 "	15 "	
40.	1 "	45 "	12 "	5 "	

On the second day numbers 10 to 16 inclusive were oviposited in by one female in succession, as also on the third day were numbers 23 to 27 and on the fourth day numbers 37 to 40. These three sets seem to show a certain uniformity in the work of a given female for a given short period. The last series is interesting in that small differences in size could be remarked in the larvae. Thus no. 38 was larger than no. 37, while nos. 39 and 40 were smaller than 37. These differences seem in this case to correspond with the variation in length of the period of heart-beat cessation.

Nos. 19 to 22 had been oviposited in earlier in the same morning, but had completely recovered before the second operation.

I have seen very little of the voiding and vomiting mentioned by Altson as resulting from the sting of the Braconid. The same observer (1920, p. 211) noticed on several occasions maggots apparently "feign death" when touched by the *Alysia*. He remarks that "the behaviour is obviously due to the larva having been previously attacked by a female, but whether it was attributable to chemotropism, which is most probable, has not been established." I also have occasionally seen this behaviour, but the effective stimulus certainly seems to be tactile rather than olfactory. I fail to see any evidence that chemotropism is involved. In such cases the maggot remained immobile while the Braconid crawled over it, but resumed vigorous movement when the latter departed. The head was often somewhat retracted and the body slightly rounded up, but the heart was beating normally the whole time. Maggots dropped from a height lie in the same position for a varying time, as though stunned, but the heart-beat in such cases also is entirely normal.

It was frequently observed that maggots hidden beneath a skin or a layer of younger larvae were chosen for oviposition in preference to similar ones wandering at large, possibly because the former were already more or less restricted in their movements.

One interesting case of prolonged oviposition was observed. A female *Alysia* took up a position on the side of the chest of a few days' old mouse. Its wings were held immobile and folded in line with the head and thorax, the head slightly bowed, the antennae in the air, gently curved and still, the legs motionless save the hindmost pair which waved at intervals, abdomen bent almost at right angles to the rest of the trunk, its tip apparently well forward, but hidden in the hair. At intervals the abdomen was raised to the accompaniment of and perhaps assisted by the waving of the hindmost pair of legs; but it was not withdrawn far enough to show the tip, and it was again sunk in the same position. This procedure was kept up at exactly the same spot for thirty-two minutes. Could this *Alysia* have been ovipositing in a number of successive larvae through the same hole in the skin? Beneath the skin, at a point of activity I afterwards found a mass of one-third grown *Calliphora* maggots on the surface of the muscle layer.

Graham-Smith has shown that one female will oviposit in more than two hundred larvae, and that unfertilised females, though laying readily, produce only male offspring. He has found, also, that one female may produce as many as 549 eggs.

Occasionally the same larva may be oviposited in more than once ; but in such cases only one *Alysia* emerges, as normally, from the puparium.

Between bouts of oviposition the female *Alysia* is assiduous in cleaning itself. The antennae are usually cleaned first ; then the head and legs, and finally the wings, which often present a hopeless problem. In many cases the latter are cemented together with filth and cannot be separated. Altson has described and figured the wiping-pads used for the blades of the ovipositor and situated on the palp-like elements of the sheath. These function automatically when the instrument is being sheathed.

#### 4. The Larva.

The larva of *Alysia* has been described in detail in its various instars by Altson (1920). We have seen in the previous section that the parasitised maggot is nearly or quite full-fed when the egg is introduced. Altson believes he has shown that the process of oviposition acts as a stimulus to the maggot to bury itself at once. Before pupation it is difficult to demonstrate by gross dissection the presence of *Alysia*, whether as egg or young larva. Yet three or four days after pupation, under September conditions, it is rare to find anything in the puparium but a fullgrown *Alysia* larva, with occasional traces of the victim's tissue at one or other end of the case. Usually the inner surface of the puparium is polished clean. Sometimes one finds normal larvae of the Braconid within the darkened and hardened integument of larvae which have apparently failed to pupate in the normal manner. When a Muscid larva dies from other causes it either decomposes until the thin burst skin releases a dark-coloured liquid, or it dries up and shrivels. But in the case of premature pupation caused by parasitism, the integument dries in the ordinary manner save that it retains more nearly the shape and annulations of the maggot, as is normally the case with puparia of the *Fannia* type. Is the presence of the parasite producing here a reversion or merely a direct mechanical effect ? Altson considers irregularities in the shape of parasitised puparia are caused by the severance of larval muscles.

In one case a *Fannia* puparium, opened about five days after pupation, contained a half-grown *Alysia* larva and a fly pupa of the same size, on which it was feeding ectophagously. Both were laid side by side on damp blotting-paper for observation. In 20 hours not a vestige of the fly remained. This larva pupated successfully but failed to emerge ; so its identity is not entirely certain. The host had, however, been enclosed with a female *Alysia* among a number of other larvae, all of which were indubitably parasitised by this Braconid.

#### 5. Pupation.

Graham-Smith (1916, pp. 531, 540) states that *Alysia* passes the winter as a larva in the parasitised puparium. The weaving of the silken cocoon often does not take place until several weeks after the pupation of the host maggot. The cocoon is of very tough brownish silk, rough externally, but smooth and polished within. Its presence is diagnostic of parasitism by *Alysia manducator*.

When a small piece of the puparium has been removed, the *Alysia* larva in spinning its cocoon will cover the opening with silk and even draw in a little the broken edges. If the puparium be opened completely the larva will usually emerge and eventually pupate lying naked on the floor of the container. The larval cuticle splits, slips off and gathers in a small knot at the tip of the abdomen. Altson (1920, p. 205) found that in cases observed by him the larval cuticle was not attached. I do not know the cause of this discrepancy.

Larvae pupating thus nakedly made no attempt to spin a cocoon and apparently no silk was emitted, though in one case the tip of the abdomen, entangled in the larval exuviae, seemed fastened to a light and irregular pad of threads, which looked



like silk. But there was one more notable exception. A large *Alysia* larva, extracted from a *Calliphora* puparium, and placed in a glass vial of 5 mm. bore, spun a diffuse cocoon to the wall of the tube. The grub was lying upon its back, with head curved forward and a thin zone of silk forming a band round the vial for rather more than the length of the larva's body. But as though finding this diameter too great for its supply of silk, it abandoned the upper half or two-thirds of this zone and put across a horizontal partition, thus eventually constructing a roughly oval cocoon of more nearly the normal shape and dimensions, but looser in texture and less symmetrical. Of a number of full-fed larvae arranged serially in a still narrower tube, one emitted a small shapeless tangle of dark brown silk.

In about eight days after pupation, or four before emergence, under early autumn conditions, the pure white pupa begins to darken, first about the head and especially the eyes.

## 6. Emergence of Imago.

At the final ecdysis the pupal cuticle is slid back to the tip of the abdomen.

As Graham-Smith has remarked, the males emerge in numbers some time before the females begin to appear. The difference may vary from a couple of days to more than a week.

It is, of course, well-known that when a blowfly emerges, a circular cap is split from the anterior end of the puparium, and this cap itself divides diametrically. Graham-Smith has contrasted with this the behaviour of emerging *Alysia*, which is said to gnaw an irregular hole near the same end. Altson has found that the powerful and highly characteristic mandibles of imagines of both sexes are used, with an *outward* motion, to break through the wall of the puparium at this place. More often than not, in my experience, *Alysia* seems to break off a cap like that of the emerging fly itself. This was especially noticed in one batch from which over 1,500 of the Braconids emerged, and was seen also by Altson (1920, p. 207). The cap itself was prevented from splitting further by the lining of silken cocoon, a portion of which hinged it to the rest of the puparium. The line of dehiscence or cutting was in the normal position and was marked by the broken edges of the puparium. Frequently the cap fell back into place and left the case to all appearance intact, save that close scrutiny might reveal the paler cut edges of the Braconid cocoon round the base of the cap.

But *Alysia* is highly adaptable in these matters. In one case six out of eight examples emerged at the opening I had made in the puparium, but not in the cocoon, to ascertain whether *Alysia* were present. Since in one case the artificial aperture was only one millimetre wide, while the normal opening in puparia of similar size is 2.2-2.5 millimetres, this involved a considerable squeeze. The head of the *Alysia* pupa lies practically always towards the anterior end of the puparium; consequently only openings at this end were thus utilised by the emerging imago.

The breaking through of the cap, by whatever means accomplished, is frequently, and I believe, in fact, always, effected a day or more before emergence takes place. In many such puparia, with the cap detachable at the slightest touch, have been found fully-coloured, hardened imagines apparently ready for active life. In one case several females extracted thus lived for over a month and oviposited in a large number of maggots. This preparatory maturity explains the fact that *Alysia* is not only active but can readily fly immediately on leaving the cocoon. Several were seized just as they withdrew the tip of the abdomen from the puparium, and flung into the air. None dropped more than a few inches before flying with apparent ease to the adjacent window. Such analogous cases as that of emerging *Blepharocerids* are easily explained by the exigencies of the physical environment, but that of *Alysia* is less readily explicable.

Graham-Smith (1916, pp. 532, 533) remarked that a puparium attacked by the Chalcidoid, *Melittobia acasta*, could always be recognised as previously parasitised by *Alysia* by the presence of a "hard dry mass," which on dissection "invariably contained a small, black, rod-like object, probably an accumulation of excrement, always present also in dissections of healthy braconid [*Alysia*] larvae." In this connection it is remarked that the abdomen of either the male or female pupa of *Alysia* is always greatly swollen, as is also that of the imago waiting to emerge as described in the preceding paragraph. The swelling may be so extensive as to cause the intersegmental membranes in well-pigmented examples to appear as distinct white bands. Normally this hard meconial rod is evacuated, in the midst of a white, semi-fluid mass, by the imago just as it leaves the puparium. In 94 per cent. of cases the rod was found lying within the posterior end of the empty puparium. In the remaining examples the Braconid emerged with the abdomen still swollen and did not void the meconium for one to three or even more days. Until it did so it was very sluggish and quite unable to fly. One male which retained the material for nine days eventually died, apparently as a result.

## 7. Longevity of the Imago.

In 1919 (p. 379) Dr. Graham-Smith wrote that males of *A. manducator* sometimes survived in confinement for fifteen days; but that females confined with maggots invariably died in three or four. But in an oral communication in the summer of 1925 he stated that both sexes could probably be kept alive, in moderately cool storage, for five or six weeks—long enough, if necessary, to make the journey to Australia. Altson (1920, p. 213) has given longevity figures for both sexes kept under various conditions. His oldest examples—females—lived for 38 days.

The present writer has kept both sexes in glass-topped boxes with a split raisin and a constant supply of water either from wet blotting-paper or a small vial with a stopper of water-logged elder pith from which the moisture could be imbibed. The boxes were kept in an unwarmed room.

Of 17 males which emerged on the 10th September—by an oversight no females were included in this lot—the oldest lived 46 days under these conditions. The others lived for 3, 9, 10, 17 (two examples), 24, 29, 33 (two), 35, 37, 38, 42, 44 and 45 days respectively. The one which died on the ninth day had failed to void the meconium.

Five captured, ovipositing females of unknown age but considerably worn appearance were caged on 8th October; two died in 2 days, and the others in 11, 14 and 23 respectively.

Five reared females which emerged on 8th October were caged on the same date and all lived until 9th November, after which they were fertilised and used every day to oviposit in as many maggots as they would tackle during about three hours. For this purpose they were removed to a warm room, but after each ovipositing period they were returned to the cool room. Under these conditions one died on 17th November, two on 19th and two on 20th, thus attaining imaginal ages of 40, 42 (two) and 43 (two) days respectively. In cold weather, without working, it seems likely they would live very much longer.

## 8. Mating.

Mating takes place readily in captivity under the conditions described above. The male, when a female is near, spreads his wings horizontally and occasionally flaps them vigorously, meanwhile dashing about at a great speed. Eventually the female is approached with quick jerky runs, the male mounts the abdomen of the latter and bends the tip of the abdomen downward and forward to copulate, at the same time furiously flagellating the antennae and face of his mate with his own antennae.

## 9. Seasonal Cycle.

According to Graham-Smith's observations extending over a number of years, eggs laid in autumn produce a few adults in May and June and more in the latter half of September and the first half of October. During the summer *Alysia* emerged from 35 to 95 days after oviposition. Altson gives many further statistics.

In North Essex this year the last date on which adults were observed to be generally active in the field was 8th October, though single worn females were found after this date, on the baits, on 15th and 17th November respectively. Emergence occurred in the outdoor cages in small numbers until the middle of November.

Maggots oviposited in on 11th, 12th and 15th August were all found, as puparia, to contain full-fed *Alysia* larvae by 25th. Of four which were extracted from the puparia, one pupated 39 days after oviposition, one 24 days, one 26 and the fourth 27 days. The third emerged as an adult on 22nd September, thus giving the following figures, which may be taken as typical for the various stages.

From laying of egg to completion of feeding	...	...	10 days.
From this to pupation	...	...	16 "
Pupal stadium	...	...	12 "
Adult lying inert on side before evacuation of meconium	...	...	3 "
Total	...	...	41 days.

From 2,200 maggots collected full-fed on 11th August, over 1,500 adults of *Alysia* emerged from 11th September to 2nd October, with a maximum from 17th to 19th September. An examination, on 2nd October, of 107 of the remaining puparia gave the following results.

Containing dead flies or indistinguishable remains	...	40
Containing live flies ready to emerge	...	3
Containing live <i>Alysia</i> pupae	...	32
Containing dead <i>Alysia</i> pupae	...	18
Containing live <i>Alysia</i> larvae in cocoons	...	4
Containing live <i>Alysia</i> larvae naked	...	1
Containing dead <i>Alysia</i> larvae	...	9

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Of the live *Alysia* pupae some were quite white and others heavily pigmented, apparently ready to emerge. This may be taken as typical of a number of late summer or early autumn batches.

In puparia from full-fed maggots collected on 15th September and examined on 19th October, two-thirds of the parasites were present as larvae in cocoons, while the others, though full-fed, were still naked. In puparia from maggots full-fed on 22nd September most of the *Alysia* larvae were still naked on 19th October, yet in a batch derived from maggots full-fed a day earlier the larvae were almost all in cocoons. Finally, to emphasize the effect of approaching winter on the development of *Alysia*, puparia from maggots full-fed on 5th October were found on 17th November to contain, nearly all, small larvae of the Braconid with still plentiful uneaten fly remains. A few were full-grown, but none had yet spun a cocoon.

## 10. Variations in Size.

The males of *A. manducator* are generally somewhat smaller than the females. In both sexes there is very great variation in size. Altson gives the range in length as 2.5 to 6.5 millimetres; I have not found it quite so extreme. This variation is almost certainly correlated with the size of the parasitised maggot, and this in its turn depends firstly on the species concerned and secondly on the amount of food

eaten before pupation. We have seen that *Alysia* prefers maggots in the carcasses of small animals, and it is the rule rather than the exception for such objects to be very considerably "overblown" by *Lucilia* and other flies, especially in the hotter months. There is rarely food enough for all, and almost invariably there remain numbers of maggots not sufficiently developed to pupate and others only just able to do so, producing undersized puparia. We are familiar with the variation in size among adult flies attributed rightly to this cause; and *Alysia* is affected in the same way. From the most undersized puparia of *Lucilia* have been reared perfect *Alysia* imagines of the tiniest dimensions.

There is evidence that at times the *Alysia* larva may, by the small size of its host maggot, be too starved to pupate. Such was probably the case with a larva which, reared in a small *Lucilia* puparium, died without pupation, though a control extracted at the same time from a larger puparium accomplished the change successfully a week before the smaller larva succumbed.

Graham-Smith (1916, p. 524) found that individuals of both sexes of *Alysia* emerging in spring were larger than those produced the following autumn. Whether this is connected with the identity of the host, in that parasites develop more quickly in *Calliphora* than in *Lucilia*, I do not know.

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SOME CALLIPHORIDAE (DIPT.) FROM THE SOUTH PACIFIC ISLANDS  
AND AUSTRALIA.

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Having recently studied a large collection of Myioidaria from the Fiji Islands, and having received, through the courtesy of Dr. P. A. Buxton, a number of species from Samoa and other South Pacific Islands, I am able to make a revision of the CALLIPHORIDAE now before me, and to describe some new forms. I have also taken into consideration the specimens from New Zealand and from Eastern Australia in my collection, as well as the forms recently described by Aldrich, Hardy, Malloch, Patton and Surcouf, together with the taxonomic changes proposed by Senior-White, Shannon and Townsend.

It seems that some species, probably those more closely associated with man, are widely spread through the Pacific Islands; while several others seem to be very localised.

I. Subfamily POLLENIINAE.

Face carinate, retracted below, without prominent mouth-border and with the vibrissae placed considerably above it; parafacialia typically pilose; antennae rather separated at base; arista plumose on both sides. Thorax clothed with peculiar, yellowish, crinkled pile; prosternum bare; propleura and metapleura bare; st. 1:1; praes. dc. and acr. well developed. Postscutellum not developed; squama bare. Abdominal sternites free. Stem vein bare above and below; subcostal sclerite bare or setose; third vein bristly only at node (*P. rudis*), or to some distance beyond it; bend of fourth vein angular or rounded.

The main character is that of the bare prosternum. But in the genus *Nitellia*, R.-D., in which the prosternum is bare, the stem vein is ciliated above and the face is not carinate; the genus therefore belongs to the PHORMIINAE. Its position is in the vicinity of *Protocalliphora*, inasmuch as the larvae are probably parasitic on birds.\* In the Oriental genus *Polleniopsis*, Towns. 1917, the prosternum is pilose, the face is carinate, the parafacialia are bare, the stem vein is bare and the squama is hairy above in the middle; it belongs thus to the CALLIPHORINAE, in the vicinity of *Neopollenia*, together with *Pollenia pilisquama*, Senior-White 1925. The Philippine genus *Booponus*, Aldrich 1923, belongs here, showing all the main characters of the POLLENIINAE; the little known Australian genus *Palpostoma*, R.-D., seems to be related to it on account of the shortly pilose arista.

The Australian species of *Pollenia* described by Macquart (*ruficornis* 1847, *viridiventris* 1847, *tasmaniensis* 1851, *ruficornis* 1851 and *moretonensis* 1855) all seem to belong to the CALLIPHORINAE, as stated by Brauer in 1899. The genus *Sepimentum*, Hutton 1900, from New Zealand, is considered by Malloch (1924) as being the same as *Pollenia*. Of the Oriental genus *Dexopollenia*, Towns. 1917, I have seen only the following species: it shows all the typical characters of *Pollenia*, except the bare parafacialia and the broadly rounded bend of the fourth vein.

1. *Dexopollenia chrysothrix*, sp. n., ♀.

Very distinct on account of the entirely yellow body and legs, and the dense, crinkled, golden-coloured hairs of the thorax.

Type a single specimen in the writer's collection from Kiuskin, New South Wales, 20.v.1915.

\* See Bezzi, Parasitology, Cambridge, xiv, 1922, p. 36.

♀. Length of body 8 mm. ; of wing 7 mm.

Head entirely yellow ; occiput concave with a blackish spot on each side above, upper part clothed with black hairs, lower with yellowish. Frons distinctly broader than eye, convex and prominent anteriorly ; frontal stripe bare, entirely reddish, about as broad as eye ; parafrontalia clothed with yellowish dust and with scattered, rather long black hairs ; 7-8 frontal bristles ; 2 or. bent forward ; oc. well developed ; vt. of equal strength but the inner ones not decussate ; postocular bristles black, of moderate length. Antennae entirely reddish, a little shorter than the face ; third joint linear, rounded at end ; arista with the plumosity long above and shorter below, without bare terminal portion. Eyes quite bare, facets small and equal. Parafacialia twice as broad as the third antennal joint, quite bare, clothed with yellowish dust ; facial ridges quite bare ; mouth-border not prominent, not much retracted, with strong vibrissae considerably above it, and below them 6-7 bristles along the border ; face short, concave, dusted with white, with a broad, flat carina along the middle ; peristomialia very broad, only a little narrower than the vertical diameter of the eye, dusted with white behind and clothed with scattered black hairs. Palpi and proboscis pale yellowish, the former with several black bristles. All the cephalic bristles black. Thorax yellow ; disc of mesonotum opaque blackish, clothed with dense, long, crinkled, golden-coloured pile, thinner on pleurae. Both spiracles whitish. Prosternum quite bare ; propleura and metapleura bare. All bristles black, including the hypopleurals ; dc. 2+3 ; acr. 1+1 ; i.a. 1+1 ; 2 bristles below anterior spiracle ; st. 1.1 ; only 2 bristles on upper border of mesopleura ; 4-5 hypopleurals, black and strong. Metasternum bare. Scutellum pale yellowish, with the same pile as disc of mesonotum ; bristles black, 2 laterals, 1 apical, discoidal lacking. No distinct postscutellum ; mesophragma reddish, with a blackish middle spot. Calypters pale yellowish-hyaline, with whitish hind border, the lower one quite bare above ; halteres pale yellowish, with whitish knob. Abdomen entirely opaque yellowish to the end, without pattern, black-haired ; short black bristles only at hind border of 3rd and 4th segments ; venter yellowish, unspotted, with free sternites ; ovipositor retracted. Legs entirely yellowish with the tarsi black except at base ; hairs and bristles black ; front tibiae with one bristle anteriorly towards the middle ; middle tibiae with several bristles in middle. Wings yellowish-hyaline, more markedly yellowish antero-basally ; veins yellow ; sub-costal sclerite bare ; no costal bristle ; stem vein bare above and below ; basicosta yellow ; third vein quite bare at base ; bend of fourth vein as broadly rounded as in *Orthellia*, the apical cross-vein concave, the first posterior cell ending at wing-tip, rather narrowly open ; hind cross-vein oblique, but shorter than the apical one, very strongly S-shaped ; sixth vein not reaching hind border ; axillary vein long and strong, but ending some distance before reaching hind-border.

The present species differs from the genotype, *D. testacea*, Towns., from Assam, in lacking any dark brown pattern on the thorax and abdomen. *D. hazarae*, S. Wht. 1923, is evidently not congeneric.

## II.—Subfamily RHINIINAE.

Face carinate or not, receding slightly or not at all below, border of mouth much produced, and with the vibrissae considerably above it ; parafacialia bare and often callose ; antennae separated at base ; arista plumose, pectinate or bare. Thorax with crinkled pile only on pleurae, which are often densely pollinose ; prosternum and propleura pilose, metapleura bare ; st. 1.1 ; pres. dc. and acr. wanting (*Stomorrhina*, *Rhinia*) or well developed (*Metallea*). Postscutellum not developed ; squama bare. Abdominal sternites free. Stem vein ciliated above (usually with yellow cilia) and bare below ; subcostal sclerite bare ; third vein bristly only at node, above and below, or bare ; bend of fourth vein rounded.

## 2. *Rhinia testacea*, R.-D.

Of this widely spread species, recorded from the Pacific Islands by Senior-White, I have seen a specimen from Tahiti (*H. W. Simmonds*).

## 3. *Stomorhina cribellata*, sp. n., ♀.

Allied to *lunata*, Fabr., but differing in the more punctulate thorax and abdomen, and in the presence of a faint fuscous spot at the end of the second vein; not unlike some South African species, like *cribrata*, Big., but differing in the open first posterior cell, as well as in the coloration of the legs. From *discolor* (no. 4) it differs in the more elongate and more punctulate body, and different abdominal pattern.

Type ♀, a single specimen in the writer's collection from Bright, Victoria (*H. V. Davey*).

♀. Length of body 8 mm.; of wing 7 mm.

Head black; occiput concave, densely dusted with grey at border of eyes, along which there is a row of short black bristles. Frons narrower than eye, gradually widened in front; frontal stripe narrow, not broader than one of the parafrontalia, opaque, bare, dark reddish in middle, black at sides, with a narrow, elongate, grey ocellar triangle reaching to about the middle; parafrontalia densely dusted with grey, with three rows of rounded black spots, extended to the second antennal joints; on these black spots are inserted the 10-11 short frontal bristles and 2 rows of scattered, black, bristly hairs, shorter than the former; oc. thin and directed outward; vt. strong, the inner ones longer and directed outward, and before them a small prevertical pair. Lunula shining brown. Eyes bare, with very small, equal facets. Antennae widely separated at base, narrow and proportionately short, but reaching about to the vibrissae; they are dark reddish, with the third joint dusted with dark grey, attenuated but obtuse at end; arista with long plumosity only on upper side, terminating in a rather long bare portion. Parafacialia broader than the third antennal joint, bare, dusted with grey, with a broad shining black spot below and with a smaller opaque one above, and with 4-5 very small, indistinct black dots between them. The face is densely dusted with grey above, as is the rather broad middle keel, which has a shining black tubercle above, between the roots of antennae; border of mouth strongly arcuate forward and shining black; the long vibrissa is placed much above it, and there are several much shorter bristles above and below. Peristomialia very broad, dark reddish near the mouth, with a broad, shining black, bare stripe; remainder densely dusted with grey, and clothed with long, white hairs, which extend to the lower part of the occiput. Palpi and proboscis black, the former broad and flat. All the cephalic bristles black. Disc of mesonotum metallic green and rather shining, but densely covered with grey dust, which is interrupted by very numerous, oblong, black dots, disposed in approximated rows, and with short black hairs inserted on them; the scutellum is likewise dotted. The pleurae are densely dusted with grey, with only a few very small black dots on the upper part of the meso- and sternopleura, and with white hairs, more dense above and anteriorly. Spiracles white. Prosternum densely dusted with grey and clothed with long white hairs; propleura clothed with long white hairs, pteropleura likewise, but the metapleura bare; hypopleural bristles thin and black. All the bristles black; no praesutural dc. or acr., but a single pair of both very near the scutellum, which has 2 laterals, 1 apical, but no discals. Calypters white, the lower one quite bare above; halteres whitish. Abdomen flat, elongate oval, a little broader than the thorax. First and second segments distinctly yellowish, with a broad, deep black hind border, which is attenuated at sides, and, moreover, with a dark middle stripe more developed on second segment, the first segment being also black at base; third and fourth segments entirely green, but clothed like the rest with dense greyish dust, on which there are the usual oblong black dots, like those on the mesonotum, at the insertions of the short black hairs;



these dots are more developed on the sides ; the third segment has, moreover, the deep black hind border attenuated laterally ; there are no distinct bristles, but only a few bristly hairs at end of third and fourth segments, none in middle. Venter pale reddish in ground-colour, but densely dusted with grey, with many rows of elongate black dots at the insertions of the short black hairs, except on the anterior part of the first segment, which has no black dots and is clothed with short but dense white hairs ; sternites pale yellowish, grey-dusted, the first much broader than the others, all without black dots, the first with thin white hairs, the others with short black ones posteriorly. Legs black, grey-dusted, with black hairs and bristles ; tibiae and base of tarsi reddish ; front pair wanting. Wings greyish-hyaline, with yellowish veins, which are infuscated at the apex ; a faint darkish spot at end of second vein extending below to the third vein, but not reaching tip of wing. Bend of fourth vein rounded ; terminal cross-vein straight, first posterior cell narrowly open ; hind cross-vein convex outwardly ; sixth vein shorter than the axillary one, neither reaching the hind border. Stem vein with yellowish hairs above, bare below ; third vein quite bare at base, even at the node, above and below.

#### 4. *Stomorphina discolor*, Fabr.

A common Austro-Malayan species, recorded from New Caledonia and North Australia by Senior-White. I have seen numerous specimens from Fiji (*W. Greenwood*, *H. W. Simmonds* and *R. Veitch*).

I think that *Idia subapicalis*, Macquart 1847, and *Idia australis*, Walker 1849, both described from Australia, are synonymous with the present species ; and likewise *Idia murina*, Schiner, from New Zealand.

#### 5. *Stomorphina (Idielloipsis) xanthogaster*, Wied.

Already recorded from Australia by Senior-White. I have specimens from Cairns, North Queensland (*J. F. Illingworth*), and also from Key Island.

#### 6. *Metallea divisa*, Walker, 1853.

Recorded likewise from Australia by Senior-White. I have specimens from Cairns and from Gordonvale, North Queensland (*J. F. Illingworth*). Probably *Rhynchomyia gracilipalpis*, Macquart 1855, described from Australia, is synonymous.

I have not seen specimens of *Rhynchomyia incisuralis*, Macquart 1851, *Rh. tigrina*, Bigot 1874 or *Anastellorhina bicolor*, Bigot 1855. I have seen the notes on the types of the last two species by Brauer (1898 and 1899), who mentions similar forms from Samoa (but without describing them). On *Rhynchomyia dubia*, Macquart, 1855, the genus *Tricyclopsis* was erected by Townsend (*Canad. Ent.*, 1916, p. 152).

### III.—Subfamily PHORMIINAE.

#### Genus *Chrysomyia*, Rob.-Desv., s.l.

Face not carinate or receding below ; border of mouth not prominent and with the vibrissae considerably above it ; facial ridges not ciliated ; arista plumose to the end. Thorax without crinkled pile ; prosternum and propleura pilose, metapleura bare ; st. 1·1 ; pres. dc. and acr. not developed. Postscutellum not developed ; squama pilose above. Abdominal sternites free. Stem vein ciliated above (with black cilia) and bare below ; subcostal sclerite setose ; third vein bristly only at node, or some distance beyond it, above and below ; bend of fourth vein angular.

Subgenus *Achoetandrus*, nov.

Type: *Chrysomyia albiceps*, Wied.

Distinguished from *Chrysomyia* (type *marginalis*, Wied.) by having the parafrontalia in the male clothed with many rows of thin hairs, but completely destitute of frontal bristles; in the same sex the eyes are distinctly separated and have the upper facets not much enlarged.

7. *Chrysomyia* (*Achoetandrus*) *rufifacies*, Macquart.

Distinguished from *albiceps* by the presence of a strong bristle just below the prothoracic spiracle.

This well-known species is considered by Patton as a form only of *albiceps*; he also treats as a synonym, *C. putoria*, Wied., which is very different from it and African only.

*Somomyia saffrana*, Bigot 1877, and *S. melanifera*, Bigot 1877, both from Australia, are probably this same species (see Brauer, 1899); and likewise *Lucilia ispida*, Erichson 1842, as stated by Brauer (1899, p. 522) and by Patton (1925, p. 193).

Recorded frequently from Australia, New Zealand, Hawaiian Islands, etc. I have seen numerous specimens from Fiji (*W. Greenwood*, *H. W. Simmonds*, and *R. Veitch*); from Neiafu, Vavau, and Nukualofa, Tonga, February and March, 1925 (*G. H. Hopkins*); from Samoan Islands, Upolu I., Apia, August 1925 (*Hopkins*); from Honolulu, Hawaiian Islands (*F. W. Terry*); from New Zealand (*D. Miller*); from Cairns, North Queensland (*J. F. Illingworth*), Townsville, N. Queensland (*G. F. Hill*); and Bright, Victoria (*H. W. Davey*).

Subgenus *Psilostoma*, Surcouf, 1914.8. *Chrysomyia* (*Psilostoma*) *incisuralis*, Macq.

Very distinct from the other species on account of the yellow legs and the partly yellow abdomen; but in the male sometimes only the venter and the last segment are yellow, all the rest being metallic. Recorded from Eastern Australia by Macquart and by Patton; I have some specimens from Cairns, North Queensland (*J. F. Illingworth*).

Subgenus *Chrysomyia*, s. str.9. *Chrysomyia megacephala*, Fabr.

Very distinct on account of the much enlarged upper facets of the eyes in the male, and in both sexes by the black prothoracic spiracle and the dark calypters, which have a white spot exteriorly on the upper one.

Very common throughout the whole Indo-Australian Region. I have seen numerous specimens from Fiji (*R. Veitch*); from New Hebrides (*P. A. Buxton*); from Apia, Upolu Island, and from Savaii Island, Samoa (*P. A. Buxton* & *G. H. Hopkins*, *J. S. Armstrong*, *Swezey* & *Wilder*, *E. H. Bryan, Jr.*); from Nukualofa, Tonga (*G. H. Hopkins*); from Honolulu, Oahu (*F. W. Terry*); from North Queensland (*G. F. Hill*). From New Zealand it is recorded by Malloch.

10. *Chrysomyia micropogon*, Bigot 1887.

As redescribed from the type by Major Patton, the present species is distinguishable from the preceding one by the eyes of the male, which are not bisected. It is an exclusively Australian species; I have specimens from Townsville, North Queensland (*G. F. Hill*) and from Cairns, North Queensland (*J. F. Illingworth*).

Genus *Microcalliphora*, Towns, 1916.

Distinct from *Chrysomyia* chiefly in having the vibrissae placed just at the oral margin.

**11. *Microcalliphora varipes*, Macq.**

Very distinct owing to its small size and the peculiar coloration of the legs, chiefly in the male; *annulipes*, Patton 1925, is the male.

This Australian species seems to be widely spread throughout the Pacific Islands; I have seen it from Fiji (*H. W. Simmonds* and *R. Veitch*); from Nukualofa, Tonga (*G. H. Hopkins*); from Townsville, North Queensland (*G. F. Hill*); and Gordonvale, North Queensland (*J. F. Illingworth*).

**12. *Microcalliphora flavifrons*, Aldrich 1925.**

So far as is at present known, this species is exclusively Australian; I have specimens from Gordonvale, North Queensland (*J. F. Illingworth*). Easily distinguishable from the preceding on account of the partly yellow head and of the entirely yellow femora.

*M. fulvipes*, Patton 1925, is a synonym.

**IV.—Subfamily CALLIPHORINAE.****Genus *Lucilia*, Rob.-Desv. (s. l.).**

Face not carinate or receding below, without prominent mouth-border and with the vibrissae not above it; parafacialia typically bare; antennae approximated at base; arista plumose to the end. Thorax without peculiar crinkled pile; prosternum and propleura pilose; metapleura pilose or bare; st. 2:1; pres. dc. and acr. well developed. Postscutellum not developed; parasquamal tuft present; squama bare above. Abdominal sternites free and typically setose. Stem vein bare above and below; subcostal sclerite setose or bare; third vein usually bristly to the small cross-vein; bend of fourth vein angular, even if obtuse.

- 1 (14). Third longitudinal vein bristly above and below from the base to the small cross-vein or nearly so; arista plumose to the end; ovipositor simple; metallic species.
- 2 (5). Metapleura pilose (*Hemipyrellia*).
- 3 (4). Calypters white; antennae black; peristomialia grey-dusted and black-haired ... .. *fortunata*, Walk.
- 4 (3). Calypters blackish; antennae red; peristomialia golden-dusted and with orange hairs ... .. *rhodocera*, sp. n.
- 5 (2). Metapleura bare.
- 6 (11). Only two post. acr.; subcostal sclerite setose; eyes of male united (*Lucilia*).
- 7 (8). Calypters quite white; abdomen not banded ... .. *caesar*, L.
- 8 (7). Calypters blackish; abdomen banded.
- 9 (10). Species larger, with entirely hyaline wings ... .. *metilia*, Walk.
- 10 (9). Smaller species, with antero-basally infuscated wings ... .. *calviceps*, sp. n.
- 11 (6). Three post. acr.; subcostal sclerite bare; eyes of male more broadly separated (*Phaenicia*).
- 12 (13). Body rounded, metallic green, with sparse pollinosity on mesonotum; metasternum pilose ... .. *sericata*, Meig.
- 13 (12). Body elongate, metallic coppery, with rather dense pollinosity on back; metasternum bare ... .. *cuprina*, Wied.
- 14 (1). Third longitudinal vein with 2-3 bristles at extreme base only; arista with bare terminal portion; 3 post. acr.; ovipositor corneous; black species (*Paurothrix*).
- 15 (16). St. 1:1; antennae more or less red, at least at base; palpi reddish; frons of male bare between the approximate eyes ... .. *xiphophora*, sp. n.
- 16 (15). St. 2:1; antennae and palpi black, the latter dark reddish at base; frons of male pilose ... .. *bisetosa*, sp. n.

Subgenus *Hemipyrellia*, Towns., 1918.

**13. *Lucilia (Hemipyrellia) fortunata*, Walk.**

Of this common species I have not seen specimens from the Pacific Islands, but it is probably present, being widely spread throughout the Oriental Region from the Philippines to the Seychelles.

**14. *Lucilia (Hemipyrellia) rhodocera*, sp. n.**

With entirely bright orange antennae as in *L. pulchra*, Wied., but distinguished by the blackish calypters, by the orange peristomialia and beard, and by the dark blue body.

Type ♂ and type ♀, from Pago Pago, Tutuila Island, Samoa, ix. 1923 (*Swezey & Wilder*); additional specimens from Salailua, Savaii Island, "lowlands to 1,000 feet," v. 1924 (*E. H. Bryan*), and Tuafu, Upolu Island, ix. 1923 (*Swezey & Wilder*).

♂ ♀. Length of body, 7-8 mm.; of wing, 6-7 mm. Head black, clothed with dense golden dust on anterior part of the parafrontalia and on the whole of the parafacialia and peristomialia. Eyes of male in contact for a space as long as the ocellar triangle, with the anterior middle facets greatly enlarged, but not sharply separated from the posterior and inferior ones; frontal bristles thin, outer vt. not developed, oc. very thin and bent forward; frontal triangle small, with yellowish orbits and with dark reddish middle stripe. Occiput with black hairs above, and with orange hairs below. Frons of female considerably narrower than one eye, shining black near the vertex; middle stripe bare, deep black, with a small shining ocellar triangle; 9-10 frontal bristles and 2 or.; oc. strong and long, diverging outwardly; i. vt. decussate and longer than the outer ones; eyes bare, with distinctly enlarged middle anterior facets. Antennae entirely orange, with the third joint rounded at end; arista black, with long plumosity to the end, but shorter below. Parafacialia bare, narrower than the third antennal joint; peristomialia as broad as one-fourth of the vertical diameter of eye, golden-haired; vibrissae at mouth-border, which is not prominent; facial ridges ciliated with black hairs reaching to above middle; palpi orange; proboscis black. Thorax and scutellum shining dark blue, metallic, with faint whitish dust before suture; anterior spiracle brownish red; hairs and bristles black; prosternum pilose; pro-, ptero- and metapleura with long erect hairs; st. 2:1; only 2 post. acr.; scutellum with 2-3 laterals, 1 apical, 1 discal. Calypters and halteres blackish. Abdomen very dark metallic blue like mesonotum, black-haired, not banded, with indistinct terminal bristles; male genitalia not prominent; ovipositor retracted, fleshy. Legs black, with somewhat dark reddish tibiae; posterior tibiae with one exterior bristle. Wings greyish hyaline, with a very faint and diffused infuscation, a little more distinct anterobasally. Basicosta and veins black; subcostal sclerite setose; third vein bristly above to beyond middle distance from small cross-vein and more shortly so below; bend rounded but deep, apical cross-vein long and only slightly concave, the first posterior cell open before tip of wing; hind cross-vein long, oblique, slightly S-shaped.

**15. *Lucilia fergusoni*, Patton 1925.**

Distinguished from all the other species on account of its partly orange legs and abdomen; but not having seen it, I cannot decide on its systematic position. It was described from New South Wales.

Subgenus *Lucilia*, s. str.

**16. *Lucilia caesar*, L.**

This common European species is recorded from New Zealand and Eastern Australia; I have specimens from Cairns, North Queensland (*J. F. Illingworth*).



**17. *Lucilia metilia*, Walker 1849, Malloch 1926.**

Widely spread throughout Oriental and Australian Regions and described under a great many different names. I have seen one specimen from Tontouta, New Caledonia, vi. 1925 (*P. A. Buxton*).

*L. nosocomiorum*, Doleschall 1857, Patton 1925, is a synonym of this species.

**18. *Lucilia calviceps*, sp. n.**

Distinguished by the strongly basicostally infuscated wings, blackish calypters, banded abdomen, blackish prothoracic spiracle and the approximated eyes of the male. In the coloration of the wings the present species is very like *L. ditissima*, Walker, from the Philippines and other Malayan Islands, recently placed in the new subgenus *Luciliella* by Malloch (Ann. Mag. N. H. (9) xvii, 1926, p. 507), who described it under the name of *fumicosta*; but it is distinguishable by the less produced frons and by the quite bare parafacialia. It is also very like the Oriental *coerulea*, Wied., being distinguished by the blackish calypters, and by the baso-marginal infuscation of the wings. Type ♂ and ♀ in British Museum from Espiritu Santo and Epi Island, New Hebrides, vi. 1925 (*P. A. Buxton*).

♂ ♀. Length of body, 7-7.5 mm.; of wing, 6-6.5 mm.

Eyes of male very close to each other, the space between them being narrower than the breadth of second antennal joint; frons of female about half the width of an eye, with a black middle stripe. All the hairs of the head are black, even below; antennae black; arista with long plumosity to the end. Frons in profile very slightly prominent, and parafacialia narrow and quite bare, while in *ditissima* the frons is prominent for a length equal to the second antennal joint, and the parafacialia are beset with short hairs on the upper half. Oc. well developed in both sexes; female with 2 very strong or.; i. vt. long and decussate in both sexes, and the outer vt. developed in the female only. Palpi dark orange. Thorax and scutellum metallic shining green, not dusted, with only a faint whitish dust in front of mesonotum; spiracles black. Chaetotaxy normal, with only 2 post. acr.; metapleura quite bare; scutellum with 3 laterals, 1 apical and 1 discal. Both calypters blackish, the squama with narrow whitish hind border; halteres blackish. Abdomen shining metallic blue-green, not dusted; first segment entirely black; second and third segments with blue-black bands at hind border; bristles only at hind border of third and fourth segments; hairs black, denser on the black sternites; male genitalia not prominent; ovipositor fleshy. Legs quite black, black setose and black pilose; front tibiae with one bristle exteriorly a little beyond middle. Wings with black basicosta and black basal portion of costa; subcostal sclerite less setose; baso-marginal infuscation extending to the small cross-vein and to the fourth longitudinal vein, more intense in the male than in the female.

Subgenus *Phaenicia*, Rob.-Desv. 1863, Malloch 1926.

**19. *Lucilia (Phaenicia) sericata*, Meigen.**

Of this cosmopolitan species I have before me specimens from Auckland, New Zealand (*Sauter, Dr. Escher-Kündig*); from Townsville, North Queensland (*G. F. Hill*); and Sydney, New South Wales (*W. Greenwood*).

**20. *Lucilia (Phaenicia) cuprina*, Wied.**

Of this cosmopolitan species I have seen specimens from Fiji (*H. W. Simmonds*). *Somomyia pallifrons*, Bigot 1877, from Australia is possibly the present species.

Genus **Paurothrix**, nov.

This is a distinct genus rather than a subgenus of *Lucilia*. It agrees with the latter in the bare stem vein, the pilose prosternum and propleura, the bare metapleura, the bare squama, and in the well developed pres. dc. and acr.; but is distinguished by the prevalently black colour of the body, the bare terminal portion of the arista, by the third longitudinal vein having 2-3 bristles at the node only, by the parafacialia being a little hairy above, by the bare subcostal sclerite, the presence (typically) of only one anterior st., and by the apparent absence of the parasquamal tuft.

Type, *Paurothrix xiphophora*, sp. n.

The genus seems to be nearer to *Calliphora* than to *Lucilia*, inasmuch as the corneous ovipositor of the female recalls that of the Oriental genus *Hypopygiopsis*, Towns., which is related to *Cynomyia*.

**21. *Paurothrix xiphophora*, sp. n.**

Very distinct owing to the black colour of the whole body, the blackish calypters and the uniformly infuscated wings.

Type ♂ and ♀ in the Bishop Museum, Honolulu, from Safune and Salailua, Savaii Island, Samoa, 1,000-2,000 ft., and "Rain Forest, 2,000-4,000 ft.", and "Low Land, to 1,000 ft.", v.1924 (*E. H. Bryan, Jr.*).

♂ ♀. Length of body, 7.5-8.5 mm.; of wing 7-8 mm.

Head black; inferior part of parafacialia and anterior part of peristomialia dark reddish. Occiput concave above, dusted with dark grey hairs, black even inferiorly. Eyes bare, those of male practically touching, with the upper anterior facets distinctly enlarged but not sharply differentiated; frons of female narrower than an eye, with a broad, bare, blackish-brown middle stripe. Vt. much stronger in the female than in the male; oc. thin and rudimentary in both sexes; 2 very strong or. in the female. Antennae broadly reddish at base, the third joint being more or less blackish beyond the insertion of the arista; plumosity of arista rather short, and ending at some distance before apex. Parafacialia narrow, white-dusted like the postocular border, with some short, scattered hairs above; they are dark reddish like the anterior part of the black and black-haired peristomialia; mouth border not prominent; facial ridges not ciliated. Palpi dark orange. Thorax and scutellum shining black, tinged with bluish, with only a little whitish dust in front of mesonotum; pleurae shining black, with whitish-dusted sternopleura; spiracles deep black; hairs and bristles black. Chaetotaxy normal; 3 pairs of post. acr.; st. 1.1; 4-5 mesopleurals; prosternum and propleura pilose, metapleura bare; pteropleura pilose; scutellum with two laterals, 1 apical, 1 discal. Calypters entirely blackish, even the hind border of the squama being black; halteres blackish. Abdomen elongate, shining black, but more distinctly bluish than the mesonotum, not at all dusted; hairs and bristles black, the latter only at hind border of third and fourth tergites; sternites black; male genitalia very small and retracted; ovipositor prominent, strongly chitinated, corneous shining brown. Legs quite black with black hairs and setae; front tibiae with one external bristle; middle tibiae with one external, one posterior and one internal. Wings uniformly infuscated, more intensely so along costal and marginal cells, with black veins; basicosta and costa black; third vein bristly only at node above and below; bend of fourth vein forming a rounded angle; posterior cross-vein long, oblique and conspicuously S-shaped.

**22. *Paurothrix bisetosa*, sp. n.**

Near the preceding species, but distinguished by its greater size, the presence of 2 anterior st., darker coloration of antennae and palpi, and by the more pilose frons of the male.

Type ♂ and ♀, in the Bishop Museum, Honolulu, from Salailua, Savaii Island Samoa, v.1924 (*E. H. Bryan, Jr.*).

Length of body, 8-9 mm. ; of wing, 7.5-8.5 mm.

Head and its appendages as in the preceding species, but the antennae more black, not or but slightly reddish near base ; the palpi black, with dark reddish base ; frons of male distinctly pilose between the approximated eyes (while in the preceding species it is quite bare between the bristles) ; parafacialia dark-dusted, broader and more distinctly pilose on upper half. Mesonotum dull black, or only slightly shining in the female, with dark dust ; st. 2.1, stronger than in preceding. Abdomen of male rather greenish, clothed with denser whitish dust, and with longer and denser, erect black pubescence ; abdomen of female shining bluish, much less dusted ; ovipositor corneous. Legs and wings as in preceding.

Genus **Calliphora**, Rob.-Desv., s.l.

Face not carinate or receding below (except in *auronotata*, Macq.), with more or less prominent mouth-border and with the vibrissae more or less above it ; facial ridges ciliated ; parafacialia bare or pilose ; antennae approximate at base ; arista plumose, with or without bare terminal portion. Thorax without peculiarly crinkled pile ; prosternum and propleura pilose ; metapleura bare ; st. 2.1 ; pres. dc. and acr. well developed. Postscutellum not developed ; no parasquamal tuft ; squama with distinct hairs above, at least towards middle. All the abdominal sternites free, pilose or setose. Stem vein bare above and below ; subcostal sclerite bare ; third vein bristly only at node, above and below ; bend of fourth vein angular or deeply rounded.

- 1 (6). Eyes hairy ; middle frontal stripe and parafrontalia densely pilose ; postocular bristles long and curved forward ; thoracic spiracles orange, the anterior greatly swollen ; scutellum with 3-8 laterals.
- 2 (3). Legs and abdomen fulvous ; beard orange ; calypters yellowish ; arista with rather long bare terminal portion ; scutellum with numerous laterals ; 3 post. acr. (*Adichosia*) ... .. *hyalipennis*, Macq.
- 3 (2). Legs black ; abdomen metallic blue or green ; beard black ; calypters blackish ; arista with short bare terminal portion.
- 4 (5). Parafacialia bare or nearly so, half as broad as the length of antenna ; arista with long plumosity ; peristomialia half as broad as vertical diameter of eye ; antennae long ; face not receding below ; palpi orange ; scutellum with numerous laterals ; 3 post. acr. (*Neocalliphora*) *quadrifasciata*, Swed.
- 5 (4). Parafacialia densely pilose, about as broad as the length of antenna ; arista with short plumosity chiefly below ; peristomialia about as broad as vertical diameter of eye ; antennae short ; face retracted below ; palpi black ; scutellum with only 3 laterals ; 2 post. acr. (*Ptilonesia*), *auronotata*, Macq.
- 6 (1). Eyes quite bare ; frontal stripe and parafrontalia less pilose or bare ; postocular bristles shorter and less curved ; spiracles whitish, yellowish or blackish, not swollen ; scutellum with 2-4 laterals.
- 7 (30). Eyes of male united or slightly separated, the frons of male being much narrower than that of female ; squama hairy only in middle.
- 8 (15). Abdomen entirely metallic blue or green ; legs quite black ; mouth-border less prominent, the vibrissae near it.
- 9 (14). Parafacialia narrow, bare or only slightly pilose above ; squama blackish (*Calliphora*).
- 10 (11). Squama with a white hind border ; eyes of male distinctly separated ; frons of female broader than eye ; peristomialia red, but with the posterior part black and black-haired ; mouth-border much less prominent ; abdomen dusted ; scutellum with 3-4 laterals ; basicosta yellowish *erythrocephala*, Meig.



- 11 (10). Squama with black hind border; eyes of male united; frons of female narrower than eye; peristomalia wholly red, even behind, and with orange beard; mouth-border distinctly prominent; abdomen dusted only at end; posterior thoracic spiracle orange; scutellum with 2 laterals.
- 12 (13). Basicosta black; third antennal joint reddish ... *salivaga*, Bezzi.
- 13 (12). Basicosta silvery; third antennal joint black ... *leucosicta*, sp. n.
- 14 (9). Parafacialia broad and pilose above, chiefly in female; squama broadly whitish; peristomalia black with black hair; scutellum with 2 laterals; arista with rather long bare terminal portion (*Onesia*) *dispar*, Macq.
- 15 (8). Abdomen either partly yellow, or not metallic; legs often yellow; mouth-border often very prominent, with the vibrissae above it.
- 16 (19). Abdomen metallic blue in middle, yellow at base, at sides and below; mouth-border very prominent; spiracles whitish; scutellum with 2 laterals, 1 discal; last abdominal segment dusted (*Proekon*).
- 17 (18). Calypters pale yellowish; abdomen broadly yellow at sides; femora quite reddish ... *augur*, Fabr.
- 18 (17). Calypters brownish, with narrow white border; abdomen narrowly yellow at base only; femora partly black ... *aruspex*, sp. n.
- 19 (16). Abdomen never metallic blue; mouth-border less prominent; acr. numerous (*Neopollenia*).
- 20 (21). Scutellum reddish; abdomen almost entirely shining reddish, uncheckered; antennae and legs entirely fulvous ... *dichromata*, Big.
- 21 (20). Scutellum black; abdomen olivaceous or yellowish, more or less checkered.
- 22 (27). Hypopleural bristles yellowish and thin; abdominal hairs fulvous.
- 23 (26). Legs entirely fulvous; scutellum with 2 laterals.
- 24 (25). Eyes of male united and with larger facets above ... *stygia*, Fabr.
- 25 (24). Eyes of male narrowly separated and with small facets ... *hilli*, Patt.
- 26 (23). Legs black; scutellum with 3 laterals ... *tessellata*, Macq.
- 27 (22). Hypopleural bristles black and strong; abdominal hairs black.
- 28 (29). Abdomen yellowish-dusted; tibiae reddish ... *tibialis*, Macq.
- 29 (28). Abdomen olivaceous, checkered; tibiae black ... *clausa*, Macq.
- 30 (7). Eyes of male as widely separated as those of female; squama completely hairy (*Xenocalliphora*).
- 31 (32). Legs partly reddish; abdomen black ... *eudypiti*, Hutt.
- 32 (31). Legs black; abdomen metallic blue or green, slightly or not dusted.
- 33 (34). Abdomen not dusted; 2 i. a.; front tibiae with 1 bristle; spiracles orange, swollen; basicosta orange; parafrontalia and parafacialia with golden-dusted spots ... *hortona*, Walk.
- 34 (33). Abdomen distinctly dusted; 1 i. a.; front tibiae with 2 bristles ... *antiipodea*, Hutt.

Subgenus *Adichosia*, Surcouf 1914.

**23. *Calliphora* (*Adichosia*) *hyalipennis*, Macq. 1850 nec 1834.**

Of this interesting species, recorded from Australia and Tasmania, I have a female specimen from Sydney, New South Wales.

*C. ochracea*, Schiner 1868 (Patton 1925, Hardy 1926) is a synonym of this species.

Subgenus *Neocalliphora*, Br. & Berg., 1891.

**24. *Calliphora* (*Neocalliphora*) *quadrifaculata*, Swederus 1787.**

The following are synonyms of this species:—*sacra*, Fabricius 1805, *dasyophthalma*, Macquart 1843, *violacea*, Walker 1853, and *cockaynei*, Hutton 1903.



Of this beautiful fly I have several specimens from Auckland, New Zealand (*Sauter, Dr. Escher-Kündig, D. Miller*); recorded also from the Auckland Islands and from the Campbell Islands.

Subgenus *Ptilonesia*, nov.

Type, *Pollenia auronotata*, Macquart 1854.

Differs from *Onesia* in its hairy eyes, and closely allied to the preceding species (No. 24) by the orange and swollen thoracic spiracles, as well by the orange tegula and basicosta.

**25. *Calliphora (Ptilonesia) auronotata*, Macquart 1854.**

Placed in *Onesia* by Patton. I have one female specimen from Sydney, New South Wales, while Macquart and Schiner record the species from New Zealand; see also under No. 38.

Subgenus *Calliphora*, s. str.

The Pacific species No. 27 and No. 28 are not typical, approaching those of the group *Proekon*.

**26. *Calliphora erythrocephala*, Meigen.**

Of this almost cosmopolitan species I have seen specimens from Auckland, New Zealand, (*Sauter, Dr. Escher-Kündig*); it is also recorded from Australia and Tasmania, but I have not seen it from the Pacific Islands.

*Calliphora testaceifacies*, Macquart 1851, Brauer 1899, Tasmania, seems from description to be *erythrocephala*, notwithstanding that Patton (1925) has found that the type specimens are *quadrimaculata*. This is the species recorded by Froggatt (Australian Insects, 1908, p. 316) as *C. vomitoria*, L.

**27. *Calliphora salivaga*, sp. n.**

The specimens were at first believed to be *C. ruficornis*, Walker, described from Tasmania, but Patton (1925) has examined the types of that species and established that it is identical with *C. dispar*, Macquart, a species widely spread in Australia and distinguished by the entirely china-white calypters (Hardy, Proc. R. Soc. Queensland, xxxvii, 1926, p. 170).

Types ♂ and ♀, and additional specimens of both sexes, from Cuvu, Fiji, viii.1919; Nausori, Fiji, v.1921 (*R. Veitch*). Types in the British Museum.

Closely allied to *C. erythrocephala*, Meigen, but distinguished by the following characters:—Smaller, measuring 7 to 10 mm. in length, usually 8 or 9 mm.; frons considerably narrower in both sexes, the eyes in the male being almost in contact (in *C. erythrocephala* they are separated by a space a little narrower than the third antennal joint); in the female of the present species the frons is considerably narrower than the eye (in *C. erythrocephala* it is almost as broad as the eye); antennae entirely reddish to end of third joint; peristomalia, even on lower part of head and behind mouth, entirely reddish, clothed behind with orange-yellow hairs (in *C. erythrocephala* the lower part of the head is black and black-haired). On the thorax, spiracles conspicuously orange; squamae with hind border blackish and fringe dark (in *C. erythrocephala* whitish, with white fringe). The abdomen entirely shining blue, with whitish dust on fourth segment only; basicosta black (yellowish in *C. erythrocephala*), and bend of fourth vein more distinctly rounded.

**28. *Calliphora leucosticta*, sp. n.**

Closely allied to the preceding species, but at once distinguishable by the silvery *basicosta* and the black antennae.

Type ♂ and ♀ in British Museum from Malololelei, Upolu Island, Samoa, 2,000 ft., viii. 1925 (*P. A. Buxton & J. H. Hopkins*); several additional female specimens from Salailua and Safane, Savaii Island, Samoa, rain forest, 2,000–4,000 ft., v. 1924 (*E. H. Bryan, Jr.*); Malololelei, vi. 1924 (*J. S. Armstrong*).

Seems to be an endemic Samoan species.

♂ ♀. Length of body, 8–20 mm., of wing, 7–9 mm. Head black, eyes bare, with almost equal facets, but those of male a little enlarged; in the male the eyes are closely approximated, the space between them being narrower than the second antennal joint; in the female they are not much separated, the frons being distinctly narrower than one eye. Oc. strong in female, thin in male; inner vt. decussate, the outer ones not distinct in the male; frontal stripe of female black, somewhat reddish in front, bare, with a few hairs only near vertex; 2 strong or. in the female; parafrontalia grey-dusted, narrow, bare. Antennae black, with reddish basal joints; parafacialia narrow, yellowish, bare; mouth-border rather prominent; peristomialia entirely reddish, even on lower part of occiput, clothed with a dense entirely orange beard; palpi reddish. Mesonotum very dark blue, almost black anteriorly, with faint whitish dust in front and with black pubescence; pleurae black, dusted with dark grey and with black hairs; anterior spiracle orange, posterior darkish. Bristles black, dc. and acr. 2 + 3; prosternum pilose, pteropleura densely pilose, metapleura bare. Calypters entirely blackish and with black hind border, squama clothed with dark hairs towards middle; halteres black, with paler stalk. Scutellum convex, dark blue, shining, black pilose, with 2 laterals, 1 apical and 1 discal. Abdomen shining blue-green, with short, dark pubescence; second and third segments not at all dusted, except the base of second; fourth segment with whitish dust; terminal bristles not differentiated. Legs quite black. Wings as in *erythrocephala*, but with more rounded bend, as in *salivaga*, and easily distinguished by the striking silvery spot on the *basicosta*; third vein bristly at node, above and below.

Subgenus *Onesia*, Rob.-Desv.

The separation of the present subgenus from *Calliphora* is not an easy matter, as may be seen from the recent works of Stein (1924) and Shannon (1926).

**29. *Calliphora (Onesia) dispar*, Macquart 1845.**

Synonyms of this species are:—*pubescens*, Macquart 1851, and *ruficornis*, Walker 1857, Brauer 1899, Patton 1925, Hardy 1926.

I have female specimens from Mt. Kosciusko, New South Wales. It is very probable that *C. pusilla*, Macquart 1854, Brauer 1899, from Australia, belongs also here; and possibly also *C. rutilans*, Macquart 1851.

Subgenus *Proekon*, Surcouf 1914.

(= *Paracalliphora*, Townsend 1916).

**30. *Calliphora (Proekon) augur*, Fabricius 1775.**

The following are synonyms of this species:—*oceaniae*, Rob.-Desv. 1830, *selasoma*, Erichson 1842, *lateralis*, Macquart 1843, *rufiventris*, Macquart 1847, *dorsalis*, Walker 1849, *seladonia*, Schiner 1868, and *xanthura*, Bigot 1887.

In the present species the hypopleural bristles are black and strong. It is widely distributed throughout Australia and Tasmania, and is recorded from New Caledonia; I have one specimen from Sydney, New South Wales (*W. W. Froggatt*).

*Calliphora (Proekon) nigricornis*, Macquart 1850, from Eastern Australia, as redescribed and figured by Surcouf in 1914, seems to be distinct from *C. augur* owing to its black third antennal joint with shortly plumose arista. It cannot be a Tachinid, as believed by Johnston & Hardy (Proc. R. Soc. Queensland, xxxiv, 1922, p. 192).

### 31. *Calliphora (Proekon) aruspex*, sp. n.

Very near *augur* and possibly only a local variety of it, distinguished by the darker calypters, the almost entirely blue-black abdomen and by the partly blackened femora.

Type ♀ in the British Museum, a single specimen from Tanna, New Hebrides, ix.1925 (*P. A. Buxton*).

♀. Length of body, 9.5 mm.; of wing, 8 mm.

Head, its chaetotaxy and appendages as in *augur*, but the frons is distinctly narrower, being narrower than an eye. Mesonotum and scutellum with the same coloration, pruinescence, pubescence and chaetotaxy; pleurae black, dusted with dark grey, clothed with dark hairs; prosternum pilose, metapleura bare; hypopleural bristles black and strong. Calypters dark brownish, the lower one with white hind border and clothed in the middle with long yellowish hairs. Abdomen entirely metallic blue-green, shining, even on the folded part of tergites; only the sides of first and second segments are narrowly reddish; third segment not dusted, while the fourth is entirely whitish-dusted as in *augur*; hairs black, bristles not differentiated; sternites black and black pilose. Legs very dark reddish, with partly black femora. Wing-veins darker than in *augur*; basicosta yellowish; bend of fourth vein less deep and more rounded; 3rd vein with 2-3 bristles at node only, above and below.

*Amphibolosia flavipennis*, Macquart 1850, placed here by Surcouf, is a Tachinid with bare arista and developed postscutellum, abdominal sternites not visible, squama bare and abdominal macrochaetae strong. The form of the head and the coloration of the abdomen are indeed very like those observed in *augur*; I have specimens from Sydney.

*Ochromyia nudistylum*, Macq. 1854, from Australia, is likewise a Tachinid, ascribed by Brauer (1899) to the genus *Chaetophthalmus*.

Subgenus *Neopollenia*, Brauer 1899.

(= *Trichocalliphora*, Townsend 1915, same genotype).

### 32. *Calliphora (Neopollenia) dichromata*, Bigot 1887.

Easily distinguishable from the two preceding species and from the two following ones on account of its reddish scutellum.

Described from New Caledonia; I have seen some female specimens from this island, taken at Tontouta, vi.1925 (*P. A. Buxton*).

The types of the present species were examined by Brauer in 1899, and ascribed to *Anastellorhina*; he also recorded the presence of a similar undescribed species in Samoa;\* the types were also examined by Surcouf in 1914 and ascribed to *Proekon*; and finally by Patton in 1925, who considered them as belonging to *augur*, with but some slight difference in details.

As the species is a very important one and there are no adequate descriptions of it, a complete description is appended here.

♀. Length of body, 9-9.5 mm.; of wing, 8 mm. Head as in *augur*, but the frons distinctly narrower than an eye, the frontal stripe bright reddish, the antennae entirely reddish, the dust of the parafrontalia and parafacialia more yellowish, all

\* No Calliphorid resembling this species was taken in Samoa in 1924-25 by Mr. Hopkins and myself.—*P. A. Buxton*.



the hairs of the peristomalia yellow, even in front. Mesonotum as in *augur*, but scutellum and pleurae entirely reddish, only the sternopleurae being blackish grey below; hairs black on back and scutellum, yellow on pleurae; prosternum clothed with erect reddish hairs; metapleurae bare; spiracles yellowish. Scutellum with 2 laterals, 1 apical and 1 discal. Hypopleural bristles strong and black. Calypters translucent yellowish, the lower one with yellow hind border and clothed with yellowish hairs above in the middle. Halteres pale yellowish. Abdomen entirely reddish above and below, with the fourth segment densely dusted with grey; second and third segments with more or less infuscation in the middle, which is sometimes black, but never metallic; hairs black; no differentiated bristles; sternites reddish, clothed with yellowish hairs. Legs entirely reddish, except the tarsi; hairs and bristles black, but the front femora with reddish bristles below, at least in part. Wings as in *augur*, but with a distinct yellowish portion at base.

**33. *Calliphora (Neopollenia) stygia*, Fabricius 1781.**

The following are synonyms of this species:—*villosa*, Rob.-Desv. 1830, *australis*, Boisd. 1835, *rufipes*, Macq. 1835, and *laemica*, White 1843.

In the present species the prosternum is yellow-haired, the metapleurae are bare and the hypopleural bristles are very thin and yellowish.

Widely spread throughout Australia, Tasmania, and New Zealand. I have numerous specimens from Ulverstone, Tasmania; from Melbourne (*French*); and from New Zealand (*Sauter*, *Dr. Escher-Kündig*, *D. Miller*, *R. Veitch*).

**34. *Calliphora (Neopollenia) hilli*, Patton 1925.**

An Australian species, recorded also from Tasmania; not seen, but recognisable in the same way that *Chrysomyia micropogon* is distinguishable from *megacephala*; it is therefore a distinct species, not a male aberration, as considered by Hardy (Proc. R. Soc. Queensland xxxviii, 1926, pp. 170–172).

**35. *Calliphora (Neopollenia) tessellata*, Macquart 1843.**

Very like *stygia* and with the same hair-like and yellow hypopleural bristles, but distinguished by the entirely black legs. Described from New Guinea. I have one male specimen from Seaford, Victoria (*G. F. Hill*).

**36. *Calliphora (Neopollenia) tibialis*, Macquart 1846.**

Prosternum pilose; metapleura bare; hypopleural bristles black and strong. Australia and Tasmania. I have one female specimen from Sydney, New South Wales.

**37. *Calliphora (Neopollenia) clausa*, Macquart 1846.**

Very like a specimen of the European *Dasyphora saltuum*, Rond., but with strong black hypopleural bristles, etc.; prosternum pilose; metapleura bare.

Described from Australia and recorded from Tasmania; I have one male from Gordonvale, North Queensland (*J. F. Illingworth*), with the first posterior cell open.

*Calliphora elliptica*, Macq. 1847, from Tasmania (Brauer 1899, p. 525) may be a species of *Neopollenia*, like the other Australian species of *Pollenia* described by Macquart and enumerated at the beginning of the POLLENIINAE.

Subgenus *Xenocalliphora*, Malloch 1924.

**38. *Calliphora (Xenocalliphora) hortonae*, Walker 1849.**

The following are synonyms of this species:—*icela*, Walker 1849, *aureopunctata*, Macq. 1854 (Malloch 1924, Patton 1925).



A common and distinct species from New Zealand, recorded from Australia by Macquart, and by Schiner as *Onesia*, not to be confounded with No. 25. I have it from Auckland, New Zealand (*Sauter, Dr. Escher-Kündig*); recorded also from the Auckland Islands. The species is characterized by the golden spots on the anterior parafrontals and upper parafacials, the red and club-shaped palpi, the golden anterior spiracle, the golden basicosta and tegula, the entirely dark-haired squama, the metallic shining and not dusted abdomen, the strongly setose legs, etc. Prosternum with thin, pale yellowish hairs, metapleura bare, hypopleural bristles black.

**39. *Calliphora (Xenocalliphora) eudypti*, Hutton 1901.**

Described from the Auckland Islands and the Campbell Islands, especially abundant at the penguin rookeries on the Snares; not seen.

**40. *Calliphora (Xenocalliphora) antipodea*, Hutton 1901.**

Described from Antipodes Island; not seen.

It is very doubtful whether *Calliphora flavipes*, Lamb 1909,\* from Carnley Harbour, Auckland Islands, belongs really to the CALLIPHORIDAE or not; the bend of the fourth vein is said to be only slightly curved.

V.—Subfamily PHUMOSIINAE.

Genus *Caiusa*, Surcouf 1914.

Face not carinate or receding below, with the vibrissae placed at the not prominent mouth-border; parafacialia bare; antennae approximated at base; arista plumose to the end; facial ridges not ciliated. Thorax without peculiar pile; prosternum bare in middle, thinly pilose at sides; propleura pilose; metapleura pilose; st. 1-1; pres. dc. and acr. well developed. Postscutellum not developed; squama bare. Abdominal sternites free, thinly pilose. Stem vein bare, above and below; third vein bristly at some distance beyond nodes, above and below; bend of fourth forming an obtuse angle.

**41. *Caiusa surcoufi*, sp. n.**

Near *C. testacea*, Sen.-White, from India, but distinguished by the entirely yellow abdomen; from the Australian *Phumosiopsis analis*, Macq., Surcouf 1914, it is distinguished by the presence of only 2 st. and by the different coloration of the abdomen.

Type ♀, a single, rather old specimen in the writer's collection from Queensland. This is the specimen mentioned by Surcouf (1914, p. 54) and probably the species recorded by Malloch† as *Paratricyclea (Caiusa)* sp. from Australia.

♀. Length of body 8 mm.; of wing, 7 mm.

A short species, with rounded abdomen. Head with the frons not prominent and with narrow peristomialia. Occiput entirely black, with a narrow, whitish ocular border and clothed with black hairs, even below. Frons distinctly narrower than an eye, flat; middle stripe bare, parallel-sided, black, only dark reddish in front, with a narrow, greyish ocellar triangle, reaching to the middle; 8-9 frontal bristles; 2 or.; oc. strong. Eyes bare, with distinctly enlarged anterior facets in middle. Antennae entirely reddish, a little shorter than the face; arista with long plumosity to the end, that of inferior part shorter. Parafacialia very narrow, narrower than the third antennal joint, bare, white-dusted; face very concave, rounded, whitish; mouth-border not prominent, with the vibrissae very near it; peristomialia narrow, only one-sixth of vertical diameter of eye, blackish and with black hairs, with a reddish

\* Subantarctic Islands of N. Zealand, vii, Diptera, Wellington, N. Z., 1909, p. 134.

† Ann. Mag. N. H., (9) xvii, 1926, p. 497.

spot anteriorly. Palpi reddish, proboscis shining black. Thorax entirely reddish, slightly shining and darker dorsally; the short hairs are black on back and yellowish on pleurae; bristles black, acr. 2+2, but the anterior ones very small; mesopleura with a row of 4-5 bristles; hypopleural bristles black; prosternum with only a few pale hairs at sides; metapleura clothed with thin, erect hairs. Scutellum like mesonotum, with 2 laterals, 1 apical and 1 discal; mesophragma shining reddish, unspotted. Calypters and halteres pale yellowish. Abdomen entirely reddish, only the hind borders of third and fourth segments being a little bluish and shining. Legs reddish, with black terminal joints of tarsi. Wings rather broad and short, greyish hyaline, with yellowish veins; bend of fourth forming an obtuse angle; third vein with 4-5 bristles, extending nearly to mid-way from the small cross-vein.

Genus **Euphumosia**, Malloch 1926.

Same characters as in preceding genus, but the st. 2·1, the metapleura bare, the abdominal sternites setose, the third vein bristly only at node. Hypopleural bristles yellow.

**42. Euphumosia papua**, Guér.-Mén. 1830.

Synonyms:—*eristoloides*, Walker 1858, *calliphoroides*, Walker 1861, *variegata*, Bigot 1887, *papouana*, Bigot 1887, *princeps* (Schiner) Brauer 1899.

Of this Papuan species, the most beautiful Calliphorid of the whole region, I have a couple of specimens from Kuranda, Queensland (*F. P. Dodd*), besides specimens from New Guinea; it is recorded also from the Aru Islands. The species is recorded from Northern Australia by Taylor,\* Johnston & Hardy,† and by Hardy.‡ It has been placed by various authors in *Calliphora*, *Pollenia*, *Graphomyia*, *Phumosia* and *Neopollenia*, showing thus its various systematic relations; *Graptomyza* was an obvious error of Walker's, Desvoidy being quoted as the author.

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\* Proc. Linn. Soc. N.S.W., xlv, 1920, p. 203.

† Proc. R. Soc. Queensl., xxxiv, 1922, p. 193.

‡ Op. cit., xxxvii, 1926, p. 170.



# A LOCAL OUTBREAK OF THE WINTER OR MOOSE TICK, *DERMACENTOR ALBIPICTUS*, PACK. (*IXODOIDEA*) IN SASKATCHEWAN. W.

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### 1. Introduction.

The winter tick has been recorded in Canada by Hadwen (1912) and Hewitt (1915) from the provinces of New Brunswick, Quebec, Manitoba and British Columbia. The type specimens preserved in the collection of the Museum of Comparative Zoology, Cambridge, Massachusetts, were taken from a moose in Nova Scotia, as mentioned by Bishopp & Wood (1913). Its native hosts are the moose (*Alces machlis*), elk (*Cervus canadensis*), and deer (*Odocoileus virginianus* and *O. hemionus*). In the prairie provinces its occurrence is confined to the forested regions of the north, the natural habitat of its native hosts, and only rarely is it to be found on the open plains further south, where it is occasionally carried by transient animals. Economically the species has been considered as having little, if any, significance. This opinion is not shared by Bishopp & Wood (1913), whose extensive investigation of its biology in the United States led them to conclude that it is an important pest of horses and cattle during the autumn, winter and early spring. The evidence of its economic importance that we gathered on the occasion of the recent outbreak in Saskatchewan will amply support this contention.

Apart from its occurrence on the moose, which had been occasionally reported by hunters and game guardians, there is no record of its causing serious injury to live-stock in Saskatchewan until the winter of 1921-22. In the annual report of the chief game guardian of Saskatchewan for 1916 it is stated by one correspondent that carcasses of moose had been found which indicated plainly that they had died as a result of loss of vitality caused by the winter tick. Another correspondent referred to the finding of the dead bodies of seven or eight moose in a journey of six or seven miles during the previous spring. In all cases the animals presented an emaciated appearance and were all badly tick-infested. This condition of affairs has apparently recurred at intervals among the moose in the woods of Saskatchewan, west and north of Prince Albert and Battleford, where they are fairly plentiful, as well as in the big game country that lies between Tisdale and the Manitoba boundary. In some seasons the scarcity of moose is attributed entirely to the ravages committed by the winter tick. Since the moose is the chief game animal of the province and is an element of no small importance in the food supply of the Indians as well as of members of the civilised communities during the open season for shooting permitted by law, it will be readily appreciated how severe infestations may seriously interfere with the maintenance of this wild-meat commodity. On the occasion of the last outbreak, which was the subject of our investigations, it was reported by various district game guardians in



the early winter of 1921 that the moose were heavily parasitised by ticks, and that individuals had been encountered in a weakened or dying condition in the northern woods. In the district of Big River, which lies 60 miles north and west of Prince Albert, the district game guardian reported the finding of fifteen dead moose in the course of a single journey of inspection of his territory, which took him 50 miles north of Big River. In all cases the hides of the dead animals were covered with ticks. Moose in an exhausted condition had also been observed in the immediate vicinity of farm buildings, their sense of fear of human habitations having apparently been overcome by the stress of their intense parasitic condition and consequent weakness. It was not, therefore, altogether surprising to find that cattle and horses in the district of Big River became heavily infested in the winter of 1921-22. On 7th April 1922, a herd of cattle that had been wintered in the open at Big River had been driven south to Marcelin, whence they were to be transported to the market at Winnipeg. At the request of the owner, this herd was inspected by one of us (J. S. Fulton), when it was found that many of the animals were in an emaciated condition and harboured thousands of the winter tick. It was further observed that several adult female ticks had become fully engorged and were ready to drop from their hosts. As to whether there had been any mortality in the herd caused by the ticks was not ascertained. A more serious condition of affairs was encountered at the beginning of January 1922 in the herds of two neighbouring farms on the east shore of Cowan Lake, 16 miles north of Big River. Out of 150 head of live-stock, one farmer lost before the end of the winter 63 head of cattle and 44 head of horses. The losses on the adjoining farm were computed at 50 head. In both cases the animals had been allowed to feed in the woods during the winter, when the infestation was contracted. A third settler, possessing but six head of cattle, suffered no losses, the animals having been kept in the barn throughout the winter, where they were amply protected against the risk of tick infestation. From an examination of the affected animals, it was quite apparent that their reserve of strength had been drained by the multitude of ticks that they had supported. At the same time, it was recognised that the poverty of their condition had been probably aggravated by the scarcity of food in the woods and the severity of the winter. At the beginning of May 1922, when the infestation had all but run its course for the season at Cowan Lake, a few ticks were found still adhering to the surviving members of the herds. The disappearance of the snow had rendered a more plentiful supply of food available and the animals were now improving in condition. Practically all the specimens of ticks that were collected on this occasion were in an engorged condition and ready to drop. The hides of two moose that had been shot during the previous December and left lying on the ground near the farm buildings of one of the farmers were found to be still harbouring large numbers of adult ticks. In the territory south of Big River reports of large losses of cattle and horses on various farms were investigated, but in no single instance was the evidence such as to warrant the belief that these could be attributed to the winter tick. The consensus of opinion seemed to be that the fatalities were caused by starvation owing to lack of fodder during the severe winter.

Subsequent to the outbreak of 1921-22 no serious losses among domesticated animals have been caused by *D. albipictus* in Saskatchewan, and it would appear as if the infestation at Cowan Lake amongst cattle and horses was due to a set of peculiarly favourable circumstances. In the first place, during the preceding years, *D. albipictus* had been increasing in numbers on the moose, which was fairly abundant in the district, with the result that the tick had become widely disseminated in the woods. In the second place, the practice of wintering cattle and horses in the woods rendered them readily liable to infestation by the larval ticks emerging from the eggs deposited in the ground by the engorged females, which had dropped from their hosts in the previous winter. Although *D. albipictus* is a single-host tick, it is not improbable that the infestation of a host by nymphs and adults must frequently occur. Removed from one host as it rubs against the branches of trees and shrubs in the woods, these

individuals will readily transfer to another, with which they may perchance come into contact. So far as relates to the prairie provinces it is probable that sporadic outbreaks of *D. albipictus* amongst cattle and horses will be generally confined to the northern fringe of settlement, where settlers are carving homesteads from the virgin forests. With the opening up of the latter as cultivation of the land is undertaken, it will be found that the native hosts of *D. albipictus* will gradually recede from the activities of human enterprise and thus reduce the liability of winter-tick infestation amongst live-stock. Further protection will also be provided by the erection of fences around pastures in which stock is confined and by the surrender of the practice of wintering the animals at large in the open.

In the course of the investigation, only one case was encountered where a human being had been attacked by *D. albipictus*. The tick, which had been picked up from an infested horse, had become attached to the man's groin, producing a painful swelling.

## 2. Seasonal History.

The fully engorged females drop from their hosts during the winter. After the beginning of May, only a very few adults may occasionally be found on the host. Under laboratory conditions the pre-oviposition period lasted for 7-12 days, although this may be greatly extended, as instanced by the records of Bishopp & Wood (1913), where in one case it occupied 134 days. It is not improbable that oviposition is considerably delayed in the open in the case of those individuals that drop from their hosts in mid-winter when zero temperatures prevail, and it is likely that egg-laying is undertaken most actively as the temperatures increase in the spring and summer. In Saskatchewan the earliest date on which engorged females have been found on the host (moose) is 28th November. Oviposition in this case would probably be deferred until April or May. The egg-batch of any single female varies with the degree of its engorgement. Individuals that are fully replete may deposit as many as 4,000 to 5,000 eggs over a period of several days, during which there is a decided variability in the number deposited from day to day, depending on the fluctuation of the temperature. In one specific case 4,286 eggs were laid in 21 days, or an average of about 204 eggs a day under laboratory conditions. Females that were only partly engorged deposited correspondingly smaller batches.

The ovoid eggs are brownish yellow, smooth and shining. They average about 0.435 mm. by 0.415 mm. in size. Towards the end of the period of incubation, which in the case of six different batches occupied 45 to 48 days, the shell becomes transparent, revealing the developing larva, which is rendered more distinct by the whitish mass of the gut. There is apparently a short period of dormancy before hatching commences in the laboratory, and it is probable that in nature this is considerably extended. After the completion of oviposition the females become greatly reduced in size and change colour from reddish brown to a greyish brown. They may continue to live for several weeks. One shrivelled specimen, which finished egg-laying on 10th May 1922, lived until 25th July, a period of 76 days, when it was accidentally killed by being crushed. Off the host, the longevity of the males is less than that of the females, but they, too, may be remarkably tenacious of life, and in the laboratory specimens have remained alive for three months. Even exposure in the open under variable climatic conditions can be resisted successfully for long periods. Both unfed and partly-fed adults have been observed crawling actively among the hairs of moose hides three months after the animals have been killed.

In individual egg-batches hatching proceeds rapidly once it has commenced. The larvae (figs. 1, 2) collect together in a clustering mass in the vicinity of the empty transparent yellowish egg-shells. At first they are a pale brownish yellow, but gradually they assume a reddish brown colour. In the unengorged condition they average 0.72 mm. in length by 0.45 mm. in width. Should they be disturbed by any

untoward circumstance, they scatter around the walls of the vessel in which they are confined, but re-assemble in a single mass when the cause of the disturbance is removed. As they increase in age they become more active in their wanderings. Their vitality is remarkable. Larvae have been maintained alive and unfed in the laboratory at Saskatoon for 185 days, the only precaution taken being the provision of moisture on dampened filter-paper in the corked glass vials in which they were kept. At Dallas, Texas, Bishopp & Wood (1913) have kept the larvae alive for almost twice as long a period.

As to when hatching occurs in nature, we have no records. It is probable that in Saskatchewan the eggs may hatch in the soil during late summer or early autumn, and that the inactivity and massing of the larvae in bunches would serve to protect them against the deleterious effects of drought before attachment to the host was secured. Larvae that had hatched in the laboratory on 10th May 1922 were applied to guineapigs as well as to the scrotum of a ram at various times during July and August. Only a single larva among the hundreds employed succeeded in becoming

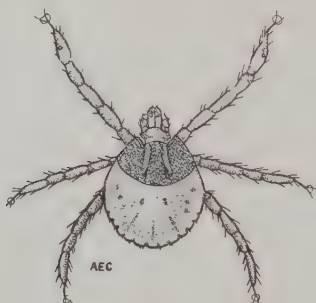


Fig. 1. *Dermacentor albipictus*, larva, dorsal aspect.

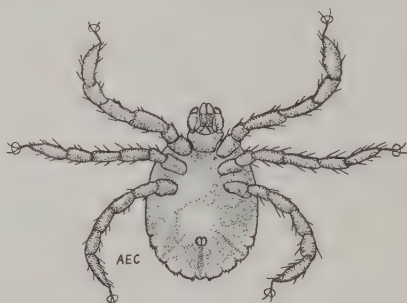


Fig. 2. *D. albipictus*, larva, ventral aspect.

attached. This occurred on the ram, but this larva, which had been applied on 21st August 1922, became detached six days later, when it was found to have been only partly fed. These experiments were continued with guineapigs as hosts with small measure of success until 19th December 1922.

In the open the larvae are first found on their hosts in the autumn, when cooler weather prevails. The stimulus to the search for a host is probably the lowering of the temperature. Abandoning the sheltering recesses of the soil, where they have remained inactive during the warmer days of summer, the larvae ascend the stems of any convenient vegetation and are ready to grasp the hair of any passing animal with their continually moving fore-legs. As to whether they may become attached to the smaller mammals such as rabbits and squirrels, which abound in the northern woods, has not been ascertained by us. *D. albipictus* was never discovered on any specimen of rabbit or squirrel examined by us, although practically all were infested by the rabbit tick, *Haemaphysalis leporis-palustris*, Pack.

The earliest date of the discovery of the larvae on the host in nature during the present investigation was 15th November 1922. A colt at Cowan Lake had been observed to be in poor condition. On being examined, it was found that numerous small oedematous swellings were distributed over the skin, from which serum had oozed and dried. In the centre of each swelling a larval or nymphal tick was found attached by its mouth-parts. In some cases the serum had flowed around and covered the larva or nymph, as the case might be. Scattered amongst the hair of the host there were found numerous moulted larval skins. The combined presence of both nymphs and larvae indicated that infestation had commenced some weeks



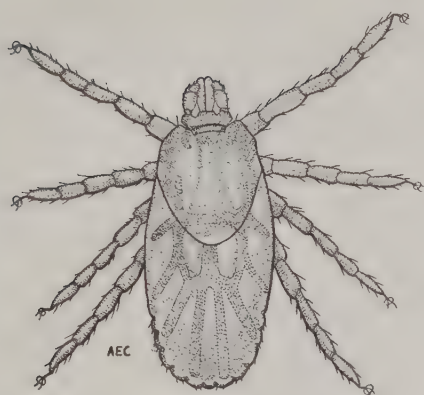


Fig. 3. *Dermacentor albipictus*, nymph, dorsal aspect.

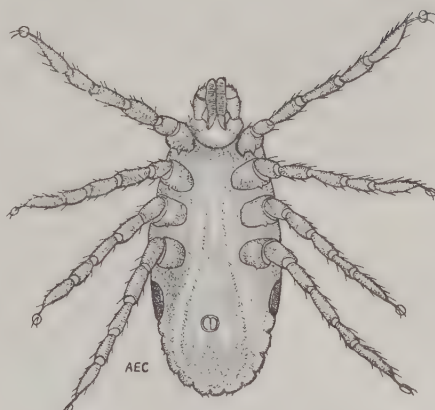


Fig. 4. *D. albipictus*, nymph, ventral aspect.

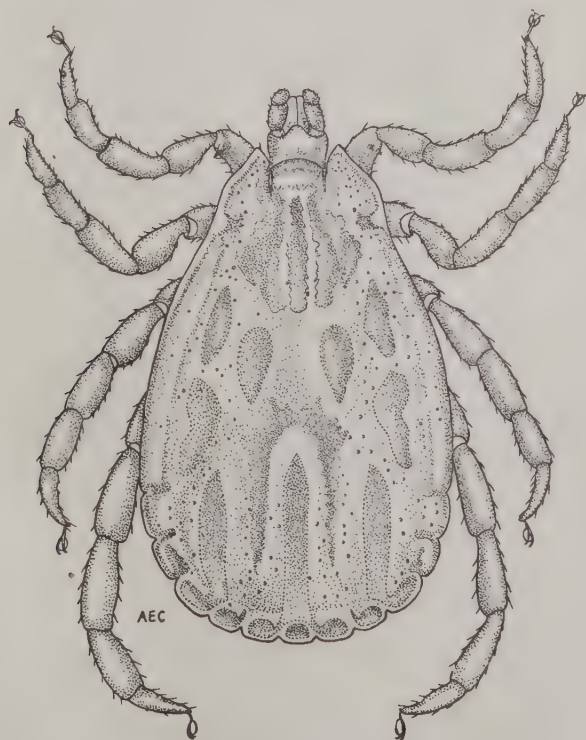


Fig. 5. *Dermacentor albipictus*, male, dorsal aspect.



previously. It must also be remembered that a host grazing in the open is continually subject to re-infestation by fresh batches of larvae, so long as these remain active. This will explain why larvae, nymphs and adults may occur simultaneously on the same host throughout the winter season. A mare that was examined on the same day (15th November) was also found to be infested with larvae and nymphs, but on an aged horse that, like the colt and mare, had been grazing in the woods, no ticks could be found. We are inclined to the belief that infestation of the host by larvae may commence as early as the end of September in Northern Saskatchewan, when the mean average temperature reaches about 50° F.

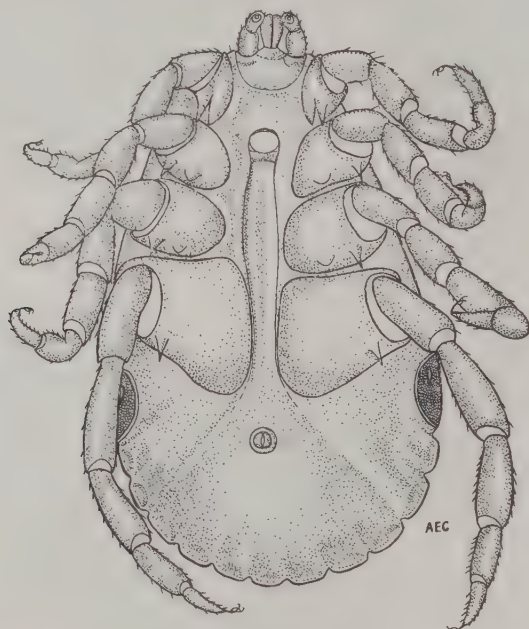


Fig. 6. *D. albipictus*, male, ventral aspect.

*D. albipictus* is a one-host tick, so that both moults occur on the host. After becoming engorged the larva undergoes the first ecdysis generally about ten days after it becomes applied. During the latter part of November and for the greater part of December the nymphs (figs. 3, 4) are more numerous than the larvae and adults. A moose killed at Grand Prairie on 20th November 1924 was carefully examined and found to be infested with ticks in the nymphal stage only, not a larva or adult being found.

After the larval moult has been completed, the abandoned skins remain attached to the host for some time. The nymph migrates only a short distance from the place where ecdysis occurred and generally becomes attached close to the site previously occupied by the larva. The body of the unengorged individual is elongate ovate in shape and measures about 2.06 mm. in length by 0.86 mm. in breadth, although there is a wide range of variability.

About two weeks after the moulting of the larva, the second or nymphal moult takes place, likewise on the host, and the adult emerges. From January up to the beginning of May, when the parasite finally abandons the host, the adult stage predominates. Great variation is noticeable in the size of the unengorged males and

females, correlated to some extent with the condition of repletion of the nymphs. The unengorged male (figs. 5, 6) averages about 7 mm. in length by 4 mm. in breadth, whilst the unfed female (figs. 7, 8) measures about 5.5 mm. in length by 3 mm. in breadth. The fully engorged female measures about 14 mm. in length, 8.5 mm. in

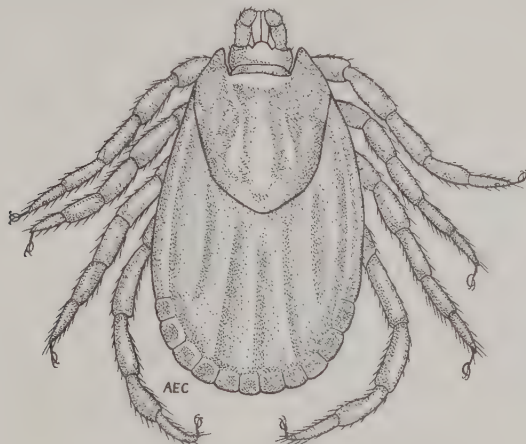


Fig. 7. *Dermacentor albipictus*, female, dorsal aspect.

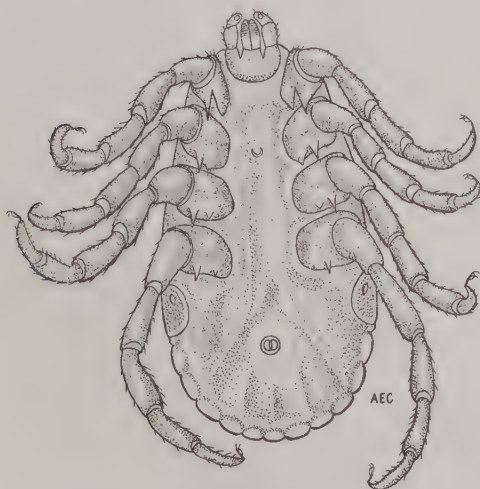


Fig. 8. *D. albipictus*, female, ventral aspect.

breadth and 6 mm. thick. Mating occurs on the host shortly after the emergence of the adults, and the females become fully engorged about ten days after attachment. Like the nymphs, both the males and females have been observed to change their location on the host before settling down to feed. During these movements they may wander freely among the hair of the host, apparently searching for a suitable place of

attachment. Even after the mouth-parts have been inserted, the individual may withdraw its proboscis and transfer its feeding activities to another site.

### 3. Control Measures.

From the facts of its life-history in northern Saskatchewan it is evident that the liability to infestation of cattle and horses may be readily circumvented. From the beginning of May, when the last ticks are dropping from their hosts, until the end of September, when the larvae become attached, live-stock may be permitted to graze at large throughout the forest ranges. Before the end of September a general rounding up of all cattle and horses should be undertaken, and they should be confined until the following May to fenced pastures and barns that are known to be tick-free. When the rounding up has been completed, the animals should be thoroughly examined for ticks. If these should be discovered, the cattle and horses should be treated with such a cleansing solution as is recommended by Ransom & Graybill (1912), the making of which is described as follows :—

“ In preparing each 500 gallons of the standard arsenical solution, there shall be used 10 lb. of finely powdered white arsenic containing not less than 99 per cent. of arsenic trioxide, 25 lb. of sal soda and 1 gallon of pine tar. The arsenic and sal soda shall be boiled together in not less than 25 gallons of water for fifteen minutes, or longer if necessary to effect complete solution of the arsenic. Before the pine tar is added, the temperature of the solution shall be reduced to 140° F. This may be done by the addition of cold water. The pine tar shall then be added in a small stream while the solution is thoroughly stirred, after which the solution shall be immediately diluted with clear water sufficient to make 500 gallons of dip.”

In the case of small herds of cattle and horses, the treatment may be made by a hand-spraying machine, but a dipping vat will be found to be more practicable and effective where a large herd has to be handled. Of the two methods of application, the dipping vat is more reliable, in that it ensures for each animal treated a thorough wetting of the skin. To achieve this purpose the fluid in the vat should be at least 5½ feet deep, and the vat itself should have a length of 40 feet at least at the surface of the solution. A steep slide is provided at the entrance of the vat, so that each animal receives as it makes the plunge sufficient momentum to carry it to the other end completely immersed in the fluid. Whilst a single treatment is usually sufficient to rid an animal of larval and nymphal ticks, it is advisable that two treatments should be made, the second to follow the first after an interval of 7 to 10 days. Before being passed into the fenced tick-free pastures, the animals are confined to draining pens, until such time as the excess of fluid has dripped off their bodies. In these the poisonous solution should not be allowed to collect in pools, where it may be partaken of by the animals with serious results. In our northern latitudes dipping cannot be safely accomplished after September by reason of the prevailing low temperatures, which would seriously interfere with the quick drying of treated animals and would probably be attended by severe and even fatal chills. Under no pretext should infested animals be treated with mineral oils. It has been amply demonstrated that such oils in an undiluted condition are responsible for serious blistering of the skin, followed by shedding of the hair and exfoliation, especially when the animals are subsequently exposed to the direct rays of the sun.

Tick-infested fields may be cleaned by spring ploughing after the ticks have dropped to the ground. A field of about 20 acres at Cowan Lake, which had been grazed by infested cattle and horses in the autumn and winter of 1921–22, was ploughed in the spring and seeded to oats. In the late summer and autumn of 1922 the oats were grazed by tick-free animals, which were maintained within the fences of the field or in the barns throughout the following winter. Whilst they remained free from ticks, others that were allowed to roam at large in the woods became infested.

#### 4. Summary.

(1) *D. albipictus*, known as the winter or moose tick, is a common parasite of moose, elk and deer in the forests of northern Saskatchewan. As in the outbreak described in this paper, it may attack and cause serious losses among the cattle and horses of settlers which are permitted to graze in the haunts frequented by its native hosts. Deaths among the moose are frequently attributed to the ravages of the tick.

(2) The eggs of *D. albipictus* are deposited in the ground by the engorged females, which continue to drop from the hosts throughout the winter until the beginning of May. The larvae emerge from the eggs during the late summer and probably remain dormant until such time as the period of drought passes and cooler weather arrives. Attachment to the host is achieved by the larvae in the autumn, and both the larval and nymphal moults are undertaken on one and the same host. During the summer months the hosts are free from its attacks.

(3) Infestation of cattle and horses may be prevented by their maintenance in fenced, tick-free pastures or in barns from the end of September until the beginning of May. Animals that have become infested may be treated with an arsenical dip. Dipping, however, cannot be safely accomplished after September in northern Saskatchewan because of the risk of severe chills that may be contracted by treated animals consequent on the low prevailing temperatures of the autumn months.

Tick-infested fields may be cleaned by being ploughed in the spring after all the ticks have dropped. The engorged females are buried, and even though the eggs may hatch, the larvae will find difficulty in reaching the surface in the autumn to attach themselves to a host.

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# R. THE FIG WAX SCALE (*CEROPLASTES RUSCI*, L.) IN PALESTINE.

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(PLATE XX.)

## Introduction.

The cultivation of the fig tree in Palestine has not yet attained any great or highly valuable proportions, though there are many thousands of these trees scattered over the cultivatable portions of the country, all of which yield a certain amount of annual profit. In some parts a few, small, regularly-planted collections of trees exist which can, with dignity, be termed plantations.

The fig tree in this country is of hardy growth and seldom receives much attention beyond a yearly ploughing of its surrounding soil and the removal of the crop. It is, perhaps, because of its resistance to the rigours of heat, cold and dryness which are experienced in the gamut of the country's climates, and its ability to flourish and bear a crop of profitable fruit with a minimum of expenditure on upkeep, that it is so popular with the agricultural inhabitants of Palestine.

The fruit of this tree is either sold fresh or else marketed locally after a process of sun-drying, which forms a profitable industry in the hill districts and is quite capable of considerable expansion. Some eleven species of figs are grown in Palestine,<sup>1</sup> four of which are excellent for drying.

The pests of this tree are not numerous and include the fig wax scale (*Ceroplastes rusci*, L.), the Mediterranean fruit-fly (*Ceratitis capitata*, Wied.), and a recently discovered Psyllid,<sup>2</sup> which is confined to a comparatively small area. Of these the fig wax scale is by far the most important.

## Distribution and Economic Importance.

The fig wax scale is known as a pest of figs in other countries as well as Palestine and has been recorded as such in Egypt,<sup>3</sup> and Morocco,<sup>4</sup> but in neither of these countries does it appear to attain anything like the same economic importance as in this country.

In Palestine, where it has been established for many generations, it flourishes in the hill districts and is thus prevalent in the Jerusalem, Ramallah, Hebron, Nablus and Safad fig-producing areas at an elevation of 1,500 to 2,900 feet above sea-level. In the coastal areas it is almost unknown, infested trees being exceptional. In the Jordan Valley (below sea-level) it is quite unknown. Fig trees do not appear to be seriously affected by the actual presence of this insect, but the all-pervading, soot-like mould which grows on its sticky exudations, apart from its unsightly appearance, seriously hinders the natural functions of the leaves, reduces the market value of the fruit and renders it unsuitable for drying purposes. The sticky secretions of this pest during the summer-time are carried all over the foliage, branches and twigs by the heavy dews. During the winter, when all the leaves are cast, this mould remains on the naked branches.

This *Ceroplastes* appears to prefer especially a species of fig that is grown for drying purposes, known locally as "Haroubi." It also flourishes most on trees grown in a sheltered position near an abundant supply of water.

### Life-History and Habits.

Observations on the life-history and habits of *Ceroplastes rusci*, L., were made in the Jerusalem District (elevation 2,500–2,600 feet), and adult female scales were brought from this District to Mt. Carmel (elevation 990 feet) in order to make closer studies under field and laboratory conditions. Experimental infestation of a fig tree was readily accomplished by attaching twigs bearing adult scales to the branches of the tree to be infested. At an elevation of some 2,500 feet, late in April or early in May, when the foliage of the fig tree is well advanced, those adult scales which have successfully retained their position on the twigs during the winter months commence to give forth young larvae, and as many as a thousand may be produced by a large, well-grown insect.

The larvae continue to hatch out for some four or five days, and the adult females die as soon as reproduction is completed. The shells of these females remain in position for a considerable period after death and gradually lose all their colour and adhering wax.

At first the young larvae are exceedingly mobile and wander over the twigs and leaves in search of a suitable feeding spot. They are dull red in colour, without wax, and by no means conspicuous. In a week's time they have settled down and become more conspicuous owing to the production, laterally, of fifteen glistening-white, waxen processes. At this stage they prefer leaves shaded from the direct rays of the sun. The upper surfaces of the leaves are invariably chosen, usually along the mid-rib or branch ribs.

After a month they again migrate, this time to the stems of the leaves or to the upper, more tender portions of the young shoots. During these earlier stages great mortality takes place, and it is calculated that only about 3 per cent. of the larvae originally produced attain maturity, owing to predacious insects or unsuitable environment. After this migration the lateral wax processes disappear and the wax plates of the adult insect become slowly apparent. Growth is by no means uniform among individuals, being influenced by the suitability or otherwise of the settling place.

About this period the sticky secretions, previously referred to, make their appearance and increase in copiousness as maturity approaches. Two species of ants have been observed to feed on the secretion, and it is also attractive to a number of small Diptera, including the adults of the Mediterranean fruit-fly (*Ceratitis capitata*, Wied.).

In seventy or eighty days the first summer generation is sexually mature and begins producing larvae. A further generation then follows, which reaches maturity late in the autumn, but owing to the general drop in temperature at that time of year it takes somewhat longer to become fully grown. This generation passes the winter in the adult stage and produces young in the following spring, as previously described. Thus in Palestine at altitudes ranging from 990–2,600 feet the fig wax scale produces but two generations during the year. A cold winter causes some mortality among these adults, but they can withstand temperatures a few degrees below zero with no apparent inconvenience. Many adults perish in the late autumn owing to their being attached to the stalks and leaves which are shed by the fig tree at this period of the year.

### Natural Enemies.

The adults of *Ceroplastes rusci* are universally attacked in Palestine by the Hymenopterous parasite *Scutellista cyanea*, Mot. An experimental infection by this Coccid of a fig tree on Mt. Carmel was completely destroyed by the parasite, despite the fact that the scale has never been observed on fig trees in this vicinity. A Coccinellid beetle, *Chilocorus bipustulatus*, L., feeds on the larvae of the scale-insect.

**Control.**

Fumigation with hydrocyanic acid gas would undoubtedly prove highly efficacious, if practised during the winter, when the fig tree is dormant, but the costs of this procedure would be prohibitive owing to the scattered nature of fig cultivations, in many cases amounting only to a few dozen trees growing on a terraced hillside.

It has become clear that in order to destroy this insect satisfactorily it is necessary (i) to attack the adults during the winter months when there is no foliage on the trees, which reduces the amount of spray necessary, enables a higher concentration of spray material to be used and renders the object of attack clearly visible, though these easier conditions of work are counterbalanced somewhat by the resistance of the well-armoured scales to spray compounds; (ii) to spray at, or shortly after, the period of production of larvae, which, owing to their unprotected state, are readily killed by most contact insecticides. The attractiveness of this latter method is counterbalanced by the large quantity of spray necessary to cover the somewhat profuse foliage of this tree and by the difficulties experienced by any but trained personnel in correctly observing the appearance of the larvae. Further, any successful method must be cheap and easily executed if it is to find favour among cultivators of no great means.

Applications with varying strengths of paraffin emulsion, lime-sulphur, resin compounds and mineral oils at several periods of the year have all given partly successful results, and it has become clear that satisfactory control will eventually be obtained only by winter spraying either with a lime-sulphur compound or oil emulsion of high concentration, and experiments along these lines are already in hand.

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## APPENDIX.

The following technical description of *Ceroplastes rusci* (fig. 1) has kindly been prepared by Mr. F. Laing, of the British Museum :—

"*Test of Adult Female*.—Highly conical, a narrow subcircular or oval plinth sometimes forming a base; immediately above a semi-vertical series of 8 plates, 3 on each side, one frontal and one medianly posterior; plates with a semilunar depression on lower margin from middle of which project, in well preserved specimens, 2 snowy white threads; each plate marked off from its neighbour by a hollow; plates at upper margin curving inwards to form a shoulder above which rises a short cone with an oval depression in its centre containing a deposit of white wax or sometimes 2 short white threads. Colour of whole test dirty white to pale grey with a narrow horizontal band of orange-yellow or yellow-red immediately above and following convolutions of plates. Average height, 3 mm.; average diameter, 3.5 mm.

"In fully mature and larva-bearing females the convolutions and plates disappear, the shape becomes a regular cone with gently curved sides and the apical depression much less conspicuous if not entirely obliterated.

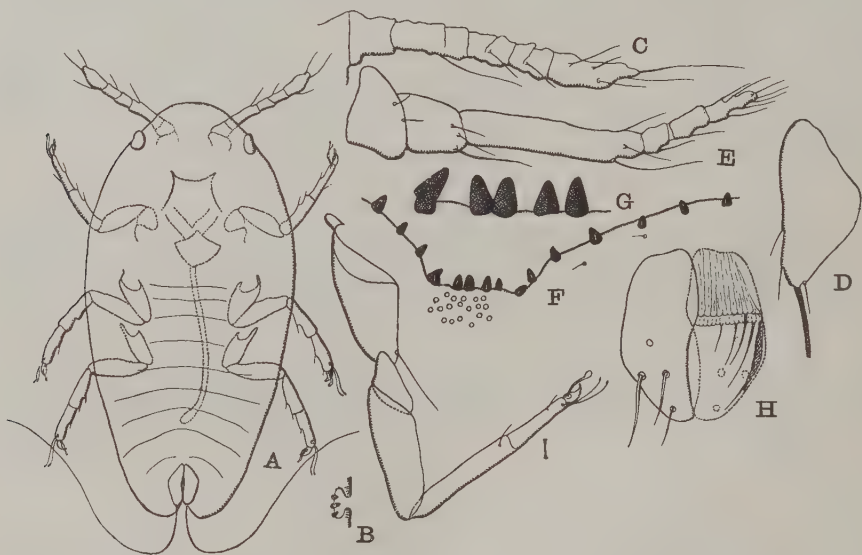


Fig. 1. *Ceroplastes rusci*, L. A, larva; B, stigmatic depression; C, antenna; D, anal lobe. Adult: E, antenna; F, stigmatic cleft and spines; G, stigmatic spines much enlarged; H, anal lobes; I, hind leg.

"*Adult Female*.—When denuded of wax dark brown, very convex, almost hemispherical, with anal lobes projecting behind as a triangular cone; whole surface strongly chitinised, with all pores practically indiscernible. Antennae with 6 segments in proportion of 15, 12, 40, 7, 7, 11; a conspicuous seta near apex of each of the first three segments and several on last. Cephalic end somewhat protruding and slightly more strongly chitinised than the rest of body. Dorsum immediately overhanging stigmatic clefts with slight protuberances—2 or 3. Stigmatic clefts with a single row of short, blunt, conical spines, all of approximately same size, extending some little way on either side of depression, the latter with a cluster of small pores (occasionally one or two spines forming an inner series immediately at the depression); short, sharp setae at remote intervals round margin. Legs normal, hind tarsus two-thirds

length of tibia, the two together subequal to length of femur and trochanter. Anal lobes surrounded by a wide, densely chitinised area obscurely perforated both laterally and anteriorly; anal lobes with anterior and inner margins more or less straight, outer strongly curved, three or four subapical dorsal spines and several fringe setae. Lower surface in old individuals broken up into distinct plate-like areas, cephalic area extending to anterior stigmatic clefts, curving behind anterior spiracles and backwards to base of antennae, a lateral area extending between the two pairs of spiracles, followed by another lateral area as far as anal lobes; an inner series of plates around buccal cavity and extending backwards to include base of legs, and at least another three median plates posterior to hind legs. Length, 2 mm.; breadth, 1 mm.

"*Female at 76 days old.*—Test waxy white, very faintly striated longitudinally, very low convex upon a subcircular or broadly oval base; plates not developed, but boundaries indicated by slightly darker lines; eight very short, snowy white pencils of wax arising from middle of lower margin of future plates, three lateral, one in front, and one behind, the latter, which may be triple, lying above the exposed dark brown anal lobes; an apical oval nipple situated in middle of a slight elevation. Height, 2.5 mm.; length, 2 mm.; breadth, 1.5 mm. When denuded of wax not differing materially from adult except in degree of chitinisation.

"*Female at 40 days old.*—Test as above but flatter and with no indication of plates. When denuded, body soft, with no sign of chitinisation except for a faint indication of area around anal lobes; eyes still visible; whole surface thickly covered with minute, blunt, tubercular wax-secreting glands; very short, thick spines scattered sparsely over derm; an irregular series, several rows deep, of small circular pores connecting spiracles with stigmatic clefts; stigmatic spines as in adult; setae separated by intervals of from once to twice their length around whole margin, with three or four much larger ones at external angle of anal cleft. Length about 1.4 mm.

"*Larva.*—Ovate, narrowing posteriorly; antennae with six segments, but with indications of having eight, iii and vi subequal and longest; legs normal, tarsus subequal to tibia, claw stout, without denticle, digitules long, slender; spiracular spines three, minute, blunt, middle one slightly the longest, situated in a deep depression; margin finely crenulated, with a few setae at remote intervals; anal plates triangular, with one long apical seta about six times length of anal plate and three-quarters length of whole body, two short subapical setae, and one near middle of inner margin. Length, 0.45 mm.; breadth, 0.26 mm." (F. Laing.)





Fig. 1. Specimens of *Ceroplastes rusei*, L., about 40 days old, on a fig leaf.  
(Author's photograph.)



Fig. 2. A dense infestation of *Ceroplastes rusei*, L., on a fig shoot,  
Jerusalem district. (Author's photograph.)





## THE SOUTH AMERICAN BOLL-WORM OF COTTON

(SACADODES PYRALIS, DYAR). *W.*

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(PLATES XXI-XXII.)

In 1925<sup>7</sup> a brief generalised account was given of the biology of *Sacadodes pyralis*, Dyar, a Noctuid moth that appeared likely to prove to be a serious pest of cotton, should the cultivation of this crop be taken up on a large scale in Trinidad. Previously little attention appears to have been paid to the potential danger, which the writer considers to be very real.

*Sacadodes* is not only very closely allied to *Diparopsis castanea*, Hampson, the Sudan bollworm, but it is also remarkably similar to that insect both in the general facies of all stages (Plates xxi and xxii) and in its bionomics.

For convenience of reference, Dyar's description<sup>1</sup> of the insect follows :—

“*Sacadodes*, new genus.

“Antennae bipectinate, the branches moderate in the male, short in the female, ciliate. Palpi porrect or oblique, the second joint long, thick; third short, nearly globose in the male, long and slender in the female. Tongue undeveloped. Eyes large, naked. Front with roughened tubercular prominence, angular in outline. Tibiae rather densely hairy, without spines. Thoracic vestiture hairy, prothorax slightly crested, metathorax with thick divided crest; abdomen with small crest at base. Forewing with vein 9 from 10, anastomosing with 8 to form the areole; 7 from near end of areole. Hindwing with vein 5 strong, from well below middle of discocellulars; retinaculum of male, broad, not bar-shaped.

“Said to be near *Diparopsis*, Hampson, which has vein 5 of the hindwing weak and arising near the middle of discocellulars, according to Hampson's description and figure. In the present form vein 5 seems scarcely at all weaker than the other veins.

“*Sacadodes pyralis*, new species.

“Forewing clayey ochreous to purplish brown; basal and subterminal spaces darker, olivaceous brown; a narrow dark discal mark; lines lighter, the inner edging the basal dark area, angled below median vein; outer slightly curved, with a narrow dark inner edging; subterminal line straight, near and similar to the outer line. Hindwing whitish in the male, purplish brown in the female. Expanse, 30 mm.

“Two males, one female, Trinidad, B.W.I., bred from the ‘pink cotton bollworm’ (P. L. Guppy).

“Type: No. 15113, U.S. Nat. Mus.

“Both in markings and structure much like *Diparopsis castanea*, Hampson, which is destructive to cotton in South Africa.”

It may be added that the males are usually pale ochreous or greenish ochreous, while the females generally are coloured purplish brown (Plate xxi, figs. 1 and 2).

\* This study was made at the Imperial College of Tropical Agriculture, Trinidad.

### Distribution.

Dyar records the species as occurring in Trinidad (type locality), Venezuela and Argentina. In the British Museum (Nat. Hist.) there are specimens from Colombia. I have taken the insect commonly in Trinidad and also in British Guiana.

### Previous Records.

The first record of the species is Dyar's description in 1912<sup>1</sup> from material collected in Trinidad by P. L. Guppy. No reference was then made to its occurrence as a pest. The next record, 1925, appears in a list of cotton pests by S. C. Harland<sup>4</sup> who mentions the "Trinidad Boll-Worm." These two references, together with the aforementioned note by the present writer, appear to be all the published data available.\*

### Habits of Adult.

The moths emerge at or just after sundown. With hardly an exception, bred moths appeared from the pupae between 5.30 p.m. and 8 p.m. The usual time was between 6 and 7 o'clock. The imagines are nocturnal in habits and are attracted to artificial lights. Mainly females, and generally gravid, have been captured in this manner, which suggests the use of light traps among control measures, but with *Diparopsis castanea* such traps are not very effective.

Some eggs may be laid by the females even on the first night and before pairing, and probably numbers of other eggs perish through the often careless egg-laying habits of the female. The total number of eggs laid by a single female is at least one hundred. Normally, and after pairing, eggs are deposited singly upon cotton plants, the most favoured position being at the base of a half to full-sized boll, where protected by the bracts. Frequently eggs are laid more exposed on the bolls (Plate xxii, fig. 7), and when bolls are few they may be affixed to flower buds. It is, however, by no means uncommon to find them placed anywhere on the plant, on stems, leaves, etc. Most varieties of cotton have been found to be used as food-plants, especially Sea Island, American Upland, and Upland by Egyptian crosses, but Indian cottons are apparently more or less immune. Few of the latter, however, were grown. Native, perennial, wild cottons may be quite heavily infested, according to season.

### The Egg. (Plate xxii, fig. 6).

Sub-spherical, with base flattened; 0.8 to 0.9 mm. in diameter and about 0.7 mm. in height (inclusive of spines in the chorion). The chorion is sculptured in a reticulate manner with spines arising at small intervals (0.05 to 0.06 mm.). The spines have their points turned, being either knobbed or somewhat hooked. The egg base is devoid of spines. Colour, when first laid, pale sky-blue, gradually becoming greyish as hatching approaches.

Eggs hatched in from 5 to 6 days,  $5\frac{1}{4}$  to  $5\frac{1}{2}$  days being the average, but even within one batch of eggs 80 per cent. may hatch on the 5th day and the remaining 20 per cent. not until the 6th.

### The First-Instar Larva.

Length at first, 1.8 mm.; width of head 0.42 mm. The newly hatched larva is brownish or madder-white in colour, with a large dark brown head and conspicuous pronotal shield, also dark brown. Other parts of the body showing some fuscous chitin pigmentation are the thoracic legs and the tenth segment of the abdomen, in addition to the macrotrichia generally distributed over the body surface.

\*Pierce & Morrill<sup>5</sup> writing of the *Thurberia* bollworm, state that Dyar, after examining larvae from bolls of *Thurberia thespesioides*, "finds that they resemble those of *Sacadodes pyralis*, Dyar." However, the life-history given, and especially the description of the egg, show that this resemblance is purely superficial.

The silk glands are functional immediately upon hatching, and the larva when lifted off a surface is found to be attached thereto by a small strand of silk. In a few hours, or maybe a day, the larva finds its way to a boll, or if such is not available, to a flower bud or flower. Into this it commences to eat its way. One flower bud or flower is not sufficient food for a larva to reach maturity, so that for the present the behaviour of a larva attacking a three-quarters or full-sized boll will be considered.

The larva does not enter indiscriminately at any point, but generally makes first for some protection, such as that afforded by the bracts. From the fact that this behaviour occurs in darkness as well as in light the reaction cannot be altogether attributed to negative phototropism. The response may be one of positive thigmotropism or of positive hydrotropism to a more humid atmosphere, or a combination of both, but proofs are not forthcoming. Again, while a protected region is generally selected, this is by no means always so. Not infrequently the side of the boll, well away from the base, is chosen. There is another reaction, however, which the young larva shows much more constantly. This is its unwillingness or inability to commence boring into a boll if any tension due to its own weight is borne by its legs. By this is meant that if a larva is placed on a boll that has been stripped of its bracts and calyx, it will bore in anywhere on the upper half of the boll, including the vertical sides, but never will enter it from the underside, whatever the orientation of the boll. This reaction has been observed almost without exception, unless interfering factors, such as the presence of protection afforded by bracts, calyx, etc., occur. As a resultant of this complex of reactions the larva most commonly enters the proximal region of the boll where covered by the bracts.

Some larvae begin to enter at once and drill a small hole directly inwards; a minority feed upon the epidermis of the boll, depositing faeces mixed with silk over an area of a few square millimetres, which may serve as a protecting scale. After this they may bore slightly into the boll wall before they are ready for the first ecdysis. This is a critical period in the life-history of every larva. Larvae that are well inside the boll may stay there if they have reached the lint, but often they, in common with others less progressive, back out of their holes and spin a little silk with faeces intermingled upon the outside. Here they await their first moult, which occurs as a rule on the third day after hatching. Re-entry of the boll is immediate, and it is rare for the larva to appear again on the surface, unless scanty food supply compels emigration to another boll. One instance only has been observed by the writer in which a second instar larva re-emerged for the purpose of ecdysis.

One can lay down no definite rule, as behaviour varies so greatly with the inherent qualities of larvae and with the conditions of the bolls, but it may roughly be estimated that about 70 per cent. of the larvae usually reappear on the outside of the boll to undergo their first moult. While awaiting ecdysis they are helpless and have been observed to be preyed upon by Coccinellid beetles, Chrysopid larvae, and in one instance by a thrips. On the other hand, larvae that do not leave the boll for their first moult are often killed within, owing to the reaction of the boll wall tissues.

It is well known that puncture of the walls of a cotton boll by any means, whether by a steel needle, or by the stylets of a bug, stimulates cell proliferation from the walls, and this occurs no less when a *Sacadodes* larva bores into the capsule. The rate and extent of the proliferation varies with the age and variety of the boll and with many other conditions, especially physiological. It may be extremely rapid in some of the New World cottons, so that the hole made by a young *Sacadodes* can be completely closed internally in a day or so. The effect upon the larva is obvious. If it remains inside the wall of the boll without keeping down the rapidly proliferating tissue by feeding upon it, there is danger of its being crushed. The larva is bound to cease feeding for some hours and during even the shortest period sufficient restriction can have occurred to prevent a successful moult. Complete crushing of the larva is the final result.



Batches of larvae vary in their behaviour, and undoubtedly natural selection in South America has eliminated many races of *Sacadodes*, the young larvae of which either did not enter with sufficient rapidity to reach the safer lint region of the boll or did not emerge from the boll for the first moult. It would be interesting to follow this subject further. It is quite likely that *Diparopsis castanea* in Africa may not be so well equipped to attack certain of the rapidly proliferating American cottons although natural selection, with the survival of adapted forms, is only a matter of time. The experiment might be worthy of trial.

From the second instar onwards the larva remains inside the boll. Generally it devours the contents of one loculus at a time and does not pass through the interlocular septum until the food in its own loculus is more or less exhausted. The seeds especially are eaten, but the lint also, before the growth of this has stopped. The faeces of the larva are voided through the entry hole, which is enlarged from time to time and cleared of proliferated tissue. On emission faeces are white or yellowish, but oxidation results in their turning brown. There is commonly a small admixture of silk with the faeces.

From the second instar onwards the larva gradually assumes its characteristic pink or crimson colour, but larvae vary as to the extent of this crimson pigmentation. In some full-fed larvae crimson is predominant, while other larvae appear mainly of a cream or greenish white colour, having merely a suffusion of pink dorsally.

#### **The full-fed Larva.** (Plate xxii, fig. 4).

Length, 2.5 to 3 cm., and about 0.5 to 0.6 cm. in width. Body smooth, with primary setae alone present (Fracker's Noctuid group 1). Head brown or yellowish brown, 2.6 to 2.7 mm. wide. Pronotal shield well developed, as also anal dorsal plate, both yellowish brown in colour. Thoracic legs pale yellowish brown. Spiracles and mouth-parts with chitin of a darker brown colour. Body with intersegmental incisures very distinct. Colour creamy white or greenish white with crimson markings on the dorsum more or less developed. Full-fed pale larvae show merely a pink suffusion dorsally. Well-coloured larvae exhibit the following series of crimson blotches:—(1) A mid-dorsal longitudinal mark on each segment, forming a longitudinal band which is interrupted intersegmentally; (2) an oblique blotch latero-dorsally surrounding setae *a* and *b*; (3) a lateral spiracular blotch, mainly dorsal to spiracle and surrounding setae *r* and *k*; (4) a small blotch surrounding *n*. These blotches tend to become confluent on the metathorax and on the first one or two abdominal segments. On the pro- and meso-thorax, extension and fusion of the blotches are lateral, with a corresponding decrease in longitudinal dimensions, so that transverse bands tend to be formed. In the hind abdomen extension of blotches is longitudinal, with corresponding decrease in lateral dimensions, thus tending to form longitudinal bands.

The larva attains full growth about 15 days after hatching, under normal and favourable conditions. It then enlarges its entrance hole, which has served hitherto for the passage of frass, making it neatly circular and about 3 mm. in diameter (Plate xxii, fig. 8). (A number of holes measured varied between 2.7 mm. and 4 mm.) Through this widened hole, or sometimes through a new and distinct hole, the larva escapes from the boll. It is not a large hole if the dimensions of the larva passing through it are considered. From the boll the larva passes to the ground and there pupates, making a total larval life of about 18 days' duration.

The larva does not always exist under such favourable conditions, and the life-history varies accordingly. When bolls are not available the larvae feed inside flower buds or flowers and leave each place as soon as the inner parts, ovary, stamens and some petals, are devoured. In this way a larva may wander considerably in search of food. Bolls that are smaller than about 3 cm. by 1.7 cm. are also insufficient for a larva to attain maturity, and even with bolls of this size, larvae in captivity only reached about three-quarters of their full length.

Throughout larval life the silk glands are slightly functional, although as a rule little or no silk is seen after the first or second instar. When about to pupate the larva enters the ground to a depth of an inch or two, and quite commonly a naked pupa is disclosed. Using a more clayey and moister soil, earthen cocoons (Plate I, fig. 3) similar to those of *Diparopsis castanea* have been obtained, and it may be that silk is incorporated with these. Again, on two or three occasions pupae have been found under dead and withered bracts of cotton bolls, scanty silk threads occurring which may have been spun by the larvae or by spiders that were present. One pupa was found inside a boll which was still attached to a cotton plant. In this case the exit hole had not been widened in the usual manner and was so small that successful escape of the moth would have been impossible.

#### **The Pupa.** (Plate xxii, fig. 5).

The pupa resembles that of many other Noctuids. It is 13 to 15 mm. in length, smooth, with the posterior extremity bluntly pointed. The colour is brown or yellow-brown. Six dark brown spiracles are conspicuous on either side of the abdomen, the seventh being much less developed and not so dark in colour.

About three weeks are generally passed in the pupal stage. Rarely did a moth appear in less than 18 days, and only one pupa was found to exceed a month. Twenty to twenty-one days is an average. The imago appears, as has been noted, just after sunset.

The periods of the life-history in Trinidad may therefore be roughly summarised as follows :—Egg  $5\frac{1}{2}$  days, larva 18 days, and pupa 21 days.

#### **Food-plants.**

All evidence points to cotton (*Gossypium* spp.) as being the only natural food-plant, as is apparently true also of the Sudan bollworm (*Diparopsis castanea*).

A careful search was made at the end of the cotton season, with *Sacadodes* decreasing in numbers on cotton, and at other times, for larvae attacking other Malvaceae, Sterculiaceae and Bombacaceae, but with no satisfactory results. In one locality where "sorrel" (*Hibiscus sabdarifa*) was being grown next to cotton at the Imperial College of Tropical Agriculture a single larva was found by the writer feeding upon a fruit of the "sorrel" a few days after the contiguous cotton had been cut down. It seems highly probable that this larvae had migrated therefrom. A further doubtful record may be made. A boy who had been trained and directed to look for larvae brought in a full-fed specimen which he said had been found at the base of an okra (*Hibiscus esculenta*) pod. To both these records it would seem that little importance should be attached. They are possibly of interest as exceptions, but they do not prove that these species of *Hibiscus* can serve as satisfactory alternative food-plants.

#### **Parasites.**

In December 1923, an adult parasitic Braconid was found in one cage in which bolls infected with *Sacadodes* larvae were being kept. In 1925 another specimen was obtained similarly, but proof is not conclusive that these Hymenoptera were parasites of the *Sacadodes*, since no parasites have been bred from isolated larvae.

Mr. F. W. Urich tells me that he has obtained Tachinid parasites. I have found none.

From more than one hundred eggs, collected at different times in the field, no egg parasites have been bred. *Trichogramma*, which is somewhat catholic in its selection of host eggs, is known to occur in Trinidad. Possibly the spines upon the eggshell of *Sacadodes* render oviposition by the parasite difficult.

It would thus appear that if parasites of *Sacadodes* exist they exert a negligible controlling influence.

The young larva, until it is permanently within the boll, is subject to the attack of predators of various kinds, and there may be fairly heavy toll taken in this manner. When leaving the boll, prior to pupation, the larva is again subject to predators, and a Pentatomid bug, probably *Podisus* sp., has been seen to attack and kill a full-fed larva.

### Control Measures suggested.

Light traps may be used for the capture of the moths, but whether they will be of sufficient practical value or not remains to be seen. Experience with *Diparopsis* is not encouraging.

Eggs of *Sacadodes* are fairly conspicuous and could easily be collected by trained children.

Arsenicals and other stomach poisons may be found of some value against newly hatched larvae, if made to penetrate under the bracts, but the suggestion is not put forward with any confidence.

The most important control measures are bound to be cultural. The crop should come to maturity during a short, intense period; in other words, the bolling curve should show a sharp peak. This result can easily be obtained by attention to variety, spacing, and time of sowing. Beneficial effects in the control of cotton-stainers (*Dysdercus* spp.) will also accrue. At the end of the crop, fields should be cleaned up thoroughly and kept free from flowers and bolls during a close season of at least two months. At this time also the soil might well be turned to expose pupae to destruction by the sun's rays, by birds, etc.

The variety of cotton grown needs some consideration, but upon this subject no positive data can be offered at present. Indian cottons in Trinidad appear to be less attacked than New World varieties, although observations have only been made upon a small scale with the Indian. The greater hairiness of Indian cottons may be unfavourable to the young larva. Again, in Trinidad the boll period, from setting to opening, for Indian (about 40 days) appears to be less than that for American Upland (48 days) or for Sea Island (51 days).<sup>3</sup> This would give the insect a shorter period for attack.

Varieties that show rapid and marked proliferation of the boll walls after puncture would seem to be indicated, to reduce the chances of survival of the young larva, and conditions of growth tending to similar results should be aimed at, so long as these do not affect the quality or quantity of lint adversely.

In Trinidad *Sacadodes* does not usually appear upon cotton until towards the end of October or November. This is probably correlated with the scarcity of bolls during the first half of the wet season. From January onwards, in the dry season, the numbers of *Sacadodes* increase and by the end of March or April they may be so abundant that two larvae sometimes occur inside one boll. In May and June bolls and *Sacadodes* decrease in numbers. How the insect carries over from June until October has yet to be determined. The fact that no resting pupa, such as occurs with *Diparopsis*, has been noted suggests that the decrease in numbers of individuals is actual and consequent upon food shortage. There is then a gradual recovery as bolls again become more abundant. Perennial cottons are certainly a real source of danger unless kept free from bolls and flowers during the close period, and this remark particularly applies to native cottons often grown singly in peasant gardens.

It is quite clear that under natural conditions reduction in numbers of the insect occurs principally at the end of the dry season and beginning of the wet, when cotton bolls are few. Also the highest mortality during the life-cycle seems to take place between the first and second instars of the larva.

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EXPLANATION OF PLATE XXII.

Fig. 4. *Sacadodes pyralis*, Dyar, immature larva ( $\times 2$ ).

Fig. 5.     "         "         "     pupae ( $\times 2$ ).

Fig. 6.     "         "         "     egg ( $\times 20$ ).

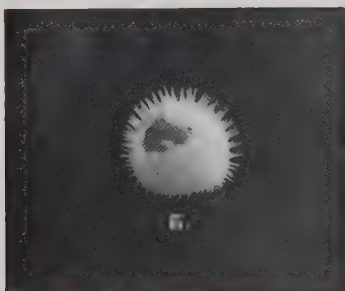
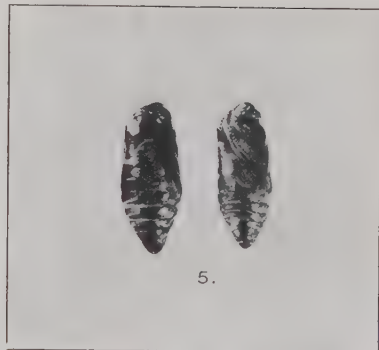
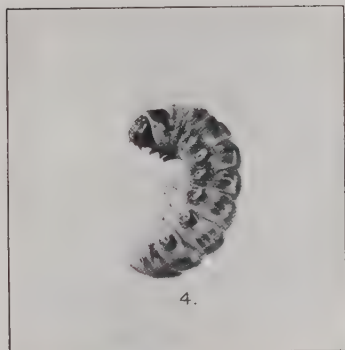
Fig. 7. Cotton boll showing empty *Sacadodes* egg at (a) and entrance hole at (b) ( $\times 1$ ).

Fig. 8. Cotton boll from which two *Sacadodes* larvae have emerged ; an uncommon condition ( $\times 1$ ).



*Sacadodes pyralis*, Dyar.  
Fig. 1, male; 2, female; 3, cocoon.





Early stages of *Sacadodes pyralis*, Dyar.





# A METHOD FOR THE APPROXIMATE CALCULATION OF THE PROGRESS OF INTRODUCED PARASITES OF INSECT PESTS. w.

By W. R. THOMPSON, Ph.D., D.Sc.

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In a series of notes and papers\* published in the last few years, the writer has attempted to apply simple mathematical methods to the study of the numerical increase of entomophagous parasites at the expense of their hosts. This work was undertaken mainly in the hope of bringing to light the general laws underlying parasitic interrelations, considered simply in their quantitative aspect. But since the publication of these papers the writer has frequently been questioned by entomologists as to the utility of the mathematical method in parasitological operations of the practical order.

As the mathematical expressions originally obtained require for their direct application a knowledge of the effective rate of reproduction of both host and parasite in the field, they cannot be utilised in their present form. Nevertheless, after some simple alterations, it has been found possible to put them into such form that they are indirectly applicable to the progress of events in the field.

In order that what follows may be intelligible, it is necessary to explain briefly how the mathematical formulae here utilised were originally obtained.

Let us suppose, to begin with, that we have a host species attacked by a single monophagous parasite, having annually the same number of generations as its host and let :

the initial number of hosts be  $= n$ ,

the initial number of parasites be  $= p$ ,

the effective rate of reproduction of the host in a generation be  $= h$ ,

the effective rate of reproduction of the parasite in a generation be  $= s$ .

It is evident that although the multiplication of both host and parasite in a generation depends upon the number of females produced, the number of hosts destroyed depends upon the total number of parasite larvae of both sexes. In other words, if the multiplication of the host in a generation is  $h$ , the total numbers of individuals produced will be  $lh$ ,  $l$  being a factor which depends on the proportion of the sexes in the species considered, so that we have  $h$  = number of females, and  $(lh-h)$  = number of males; in the same way, the total number of parasites produced in each generation will be  $fs$ ,  $s$  being the number of females and  $(fs-s)$  the number of males.

Under these conditions, it is easy to show that, other things being equal, the number of hosts in the  $t$  generation will be :

$$H_t = nh^t l - pshf \left\{ \frac{s^{t-1} - h^{t-1}}{s - h} \right\} \quad (1)$$

and the number of parasites :  $P = ps^t f \quad (2)$

The number  $t$  of generations required for the extermination of the host by its parasite will be :

$$t = \frac{nl}{pf} \quad (3)$$

if the reproductive rates of host and parasite are equal, and :

$$t = \frac{\log \left\{ \frac{na - nl + pfa}{pfa} \right\}}{\log a} \quad (4)$$

\* Comptes Rendus de l'Ac. des Sciences, Paris, May 1, May 29, June 19, July 3, 1922; Revue Generale des Sciences, Paris, April 15, 1923; Ann. Ent. Soc. Amer. 1923; Ann. Fac. Sciences, Marseille II. ser. T. II. fasc. II, 1924.

if the reproductive power of the parasite is superior to that of the host, so that :

$$[s = ah, a \text{ being} > 1.$$

Finally, the percentage of hosts parasitised in the  $t^{\text{th}}$  generation will be :

$$a = \frac{100 \ p f}{nl - pf (t-1)} \quad \text{-----} \quad (5)$$

if the reproductive power of the parasite is equal to that of the host, and :

$$a = \frac{100 \ p \ a^t f}{nl - pf \left\{ \frac{a (a^{t-1} - 1)}{a - 1} \right\}} \quad \text{-----} \quad (6)$$

if the reproductive power of the parasite is greater than that of the host as in the case covered by (4).

It is supposed that each female deposits only a single egg in each host attacked. In nature, the eggs of parasites are apparently distributed, as a general rule, in approximate conformity with the laws of chance. It has, however, been shown in one of the papers cited above\* that this fact, which might seem at first sight to complicate matters immensely, has in reality little importance, and that the difference in the progress of events in the two hypotheses—distribution of eggs by chance and distribution by choice—is not only very slight, but practically constant. In the case of parasites reproducing more rapidly than the host (no matter how rapidly) the formula (4) can be corrected for the factor of chance by the simple addition of 1 generation to the value obtained for  $t$ .

In order further to simplify the process of calculation, we may suppose that the proportion of sexes is equal in both parasite and host. Numerical equality of the sexes is, of course, not invariable among parasitic insects, but it exists in the majority of species, so that this assumption will be sufficiently accurate for practical purposes at present. We have thus :

$$l = f$$

in which case these symbols disappear from our formulae.

Let us now consider the application of these formulae to practical cases. Suppose that we have introduced a parasite in an area inhabited by an important pest, and that after it has become definitely established and generally distributed throughout the area we wish to arrive at some idea of the further time necessary for it to subjugate the pest, supposing that it can continue to multiply in the future at the same rate as in the past.

This information could be obtained directly from equation (3) or (4), provided that we knew the true values of the various symbols comprised in the formulae. These symbols represent, as we have seen, the initial number of hosts, the initial number of parasites and the ratio between their effective rates of reproduction.

The only data actually available in the vast majority of such cases, however, are (1) the initial number of parasites liberated, and (2) the percentage of infested hosts at the time the calculations are undertaken.

Assuming that these figures are reasonably accurate, our problem then is to extract from them the information required to enable us to make a rough application of our formulae (3) or (4). The method here suggested for performing this operation is as follows :—

\* 1924, Ann. Faculté Sciences, Marseille.

After the simplifications mentioned above, our equation for the percentage of parasitism in the  $t^{\text{th}}$  generation is :

$$a = \frac{100 p a^t}{n - p \left\{ \frac{a^t - a}{a - 1} \right\}}$$

From this by transforming and transposing, we get :

$$t = \frac{\log \left\{ \frac{na(a-1) + pa}{100 p(a-1) + pa} \right\}}{\log a}$$

Now, if  $n$  is very large in comparison with  $p$ , as is always the case in practical operations where the initial number of parasites is always small compared to the initial number of hosts, we can neglect  $pa$  and  $pa a$ . Further, as in what follows we shall need to consider only the *ratio* between the populations of host and parasite at the beginning of our experiment, we can put  $p = 1$ .

Our formula then becomes :

$$t = \frac{\log \left\{ \frac{na}{100} \right\}}{\log a}$$

$$\log a = \frac{\log (na) - 2}{t} \quad (7)$$

This formula is sufficiently accurate for any tests which it is possible to conduct in a field of such complexity with the methods at present available.

In order to utilise it we have only to write in the known values of  $a$  and  $t$  and then give to  $n$  a series of values such that between their extreme limits the true value is certain to be included.

Suppose, for example, we have a case in which 10 generations have elapsed from the time our parasite colony was liberated, and that the general average parasitism determined by sampling over the whole of the infested area is now 10 per cent. Our formula then becomes :

$$\log a = \frac{\log (10 n) - 2}{10}$$

Giving to  $n$  a series of values from  $n = 10^3$  to  $n = 10^{14}$ , which we may safely assume include the true value, we obtain values for  $a$  as follows :

$n$	$10^3$	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$	$10^9$	$10^{10}$	$10^{11}$	$10^{12}$	$10^{13}$	$10^{14}$
$a$	1.58	1.99	2.51	3.16	3.98	5.01	6.31	7.94	10	12.59	15.85	19.95

$a$  being, as will be recalled, the ratio between the rates of reproduction of host and parasite and always greater than unity.

We can now utilise formula (4), which, when simplified by the assumption that the proportion of sexes is equal in both host and parasite and corrected for the factor of chance distribution, becomes, when  $p$  is made equal to 1 :

$$t = \frac{\log \{n(a-1) + a\}}{\log a}$$

Giving to  $a$  the minimum, intermediate and maximum values :  $a = 1.58, 5.01$ , and  $19.95$ , we obtain for the time *still* necessary before the host is exterminated, the values shown in the following table :—

$n$	$10^3$	$10^8$	$10^{14}$
$a$	1.58	5.01	19.95
$t$	4.3	2.3	1.7

In the example just given, an enormous variation in the estimate of the initial population of hosts will thus not produce a serious alteration in the final result. The case studied is one in which the increase of the parasite has been rapid. Let us now



take one in which its increase has been very slow, so that to attain a parasitism of 10 per cent. 100 generations have been required.

Putting  $n = 10^3, \dots, 10^{14}$  as before, we obtain the following values :

$n$	$10^3$	$10^4$	$10^5$	$10^6$	$10^7$	$10^8$	$10^9$	$10^{10}$	$10^{11}$	$10^{12}$	$10^{13}$	$10^{14}$
$a$	1.04	1.07	1.09	1.12	1.14	1.17	1.20	1.23	1.25	1.28	1.31	1.34

From which we have :

$n$	$10^3$	$10^8$	$10^{14}$
$a$	1.04	1.17	1.34
$t$	9.3	6.7	5.3

The difference between the results obtained from the maximum and minimum values of  $n$  is greater than in the first example, but not inordinately so, while the difference between the two higher estimates is, as before, quite inconsiderable.

Thus, whether the parasite is increasing slowly or rapidly, the error in the estimation of the initial host population may be considerable without notably affecting the final result of our calculations as to the time required for control, especially when, as in practice, the initial population is very large.

But in addition to the error in estimating the initial host population mistakes may be made in evaluating the true percentage of parasitism over the whole area.

To show the effect of such errors, let us give to  $n$  the three values  $10^3$ ,  $10^8$ , and  $10^{14}$ , and in each of these cases put  $a$  equal to a series of values from 2 to 20. We then obtain for  $a$  and  $t$ , the following results :—

$n = 10^3$					
$a$	2	5	10	15	20
$a$	1.35	1.48	1.58	1.65	1.69
$t$	9.7	6.1	4.3	3.5	3.10
$n = 10^8$					
$a$	2	5	10	15	20
$a$	4.26	4.67	5.01	5.21	5.37
$t$	3.50	2.80	2.30	2.10	1.90
$n = 10^{14}$					
$a$	2	5	10	15	20
$a$	16.98	18.58	19.95	20.75	21.38
$t$	2.30	2.02	1.70	1.65	1.50

From which it appears clearly that although an error in the estimate of percentage parasitism has a distinct, though rather slight, effect when one is dealing with small host populations, its importance is much less in the case of large populations, which are precisely what one has to deal with in practical investigations.

When the parasite develops slowly, taking 100 generations to attain the percentage on which our calculations are based, a variation in the estimate of parasitism will have the following results :—

$n = 10^3$					
$a$	2	5	10	15	20
$a$	1.03	1.04	1.047	1.05	1.054
$t$	31	15	9.3	6.5	5.30
$n = 10^8$					
$a$	2	5	10	15	20
$a$	1.15	1.16	1.17	1.177	1.18
$t$	15.4	9.9	6.7	5.2	4.4
$n = 10^{14}$					
$a$	2	5	10	15	20
$a$	1.32	1.34	1.349	1.354	1.358
$t$	10.2	7.1	5.3	4.3	3.7

In this case the results of the error, as before, are more important when one is dealing with small populations than with large, the difference in the results of the maximum and minimum figures being respectively 25, 11 and 6 generations, approximately, with the populations of  $10^3$ ,  $10^8$ ,  $10^{14}$ .

While the actual errors due to a mistake in percentage estimation with a parasite that increases slowly are thus greater than with the parasite that increases rapidly, they are still relatively small considered in relation to the total time required for control. Nevertheless, this estimate constitutes the most important part of the whole operation.

The estimate of the initial host population at the beginning of the experiment is no doubt difficult, but as we have seen, enormous errors can be made in regard to this point with little effect upon the ultimate results. In any event, it seems possible in some instances to arrive at an idea of the value of this estimate by considering the ratio between the reproductive rates of host and parasite to which the estimate of the host population leads. It is true that the potential reproductive rates of organisms, as determined by anatomical investigations or even by laboratory experiments, may be and often are very different from their effective rates of increase in the field. Nevertheless, a careful comparison will sometimes permit us to eliminate improbabilities. Thus in the first example taken above, the value of  $10^{25}$  for  $n$ , would lead to a value for  $a$  of about 250. But this means that the parasite reproduces 250 times as rapidly as the host. So great a difference between the reproductive capacities of host and parasite ought to be apparent even under laboratory conditions. If there are no signs whatever of its existence, the probability is that our calculations and, in particular, our estimate of the initial host population, are incorrect and the latter much too high.

It will be noted that we have not considered cases in which the parasite reproduces either less rapidly than, or at the same rapidity as, the host. It would be easy to show that in the first case, the parasite will never subjugate the host unless its initial population is much larger in relation to that of the host than is ever the case in any practical undertaking. If the reproductive rates of parasite and host are equal, the parasite will eventually exterminate the host, no matter what be the ratio between the initial populations; but as is evident from (3), in cases such as those encountered in practical work, where the host population is very large in relation to that of the parasite, the advance of the latter will be so slow as to be practically imperceptible. In such cases investigations conducted at intervals will reveal the continued presence of the parasite, but for a long series of years there will be no definite indications of an increase in its numbers. These cases need, therefore, not be considered in practice.

It is highly desirable that the simple method here outlined should be applied and tested in practical operations, where facilities for obtaining the necessary data exist. It may indeed be found that even after careful estimates have been made, the extinction of the host insect by the parasite does not occur until long after the time when it is expected, or does not take place at all. This, however, is quite as interesting from a scientific standpoint as the fulfillment of the predictions based on the formulae. Such a result may indicate, for example, that after a certain percentage of parasitism is reached, the parasite no longer increases, the reason being that only a fraction of the total host population is available to the parasite in any generation. In such cases, the fact that events do not occur as predicted might thus lead indirectly to discoveries of considerable value in connection with the general problem of parasite control.



# THE INFLUENCE OF SOME PHYSICAL AND CHEMICAL CONDITIONS OF WATER ON MAY-FLY LARVAE (*CLOËON DIPTERUM*, L.).

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## Introduction.

The important influence of the physical and chemical conditions of water on the bionomics of organisms has long been recognised, but it is only recently that entomologists have started examining critically the environment of aquatic insects. The few papers that exist on the subject are, however, mostly concerned with mosquitos. The most recent work is that of Senior-White (1926), some of whose main conclusions are that the dissolved oxygen is not a limiting factor in mosquito distribution and that the residual pH (the pH after the water has been shaken to get rid of the dissolved  $\text{CO}_2$ ) is more important than the natural one, implying thereby that carbon dioxide, like oxygen, has a very insignificant bearing in mosquito ecology. These findings, especially as regards the importance of the carbon dioxide, are very extraordinary for an aquatic organism, but in the case of mosquitos they are what one would expect, in view of the fact that the respiration of mosquito larvae is mostly independent of the gases dissolved in water. Hence the conclusions of Senior-White and of other mosquito workers cannot very well apply to true aquatic insects. Therefore no apology is needed for reporting some observations on the above subject made on insects like the may-fly larvae.

Moreover, while entomologists recognise the importance of pH, they do not yet seem to appreciate fully the specific effect of carbon dioxide apart from the hydrogen ions. The works of Jacob (1920) on tadpoles, Protozoa, etc., of Smith & Clowes (1923-24) on Echinoderms, of Fraser (1925), Haywood (1925) and others, show that at the same pH the medium has different effects on organisms according to whether it contains much or little  $\text{CO}_2$ . Since this conclusion is of great ecological importance, and since, so far, no insect has been studied from this point of view, it was thought desirable to determine whether it holds good in the case of insects as well.

## Material and Methods.

The may-fly larvae were collected near Plymouth during the summer of 1926. Endeavour was made to select larvae of the same age and size for all experiments. The middle-aged larvae afforded more consistent results and were mostly used. Sometimes larvae died in experimental bottles while moulting; results obtained from them were discarded.

The pH readings were taken by the colorimetric methods, using the sulphon-phthalein indicators (Clark, 1922).

The oxygen determinations were made by Winkler's method, using N/50 thio-sulphate solution.

For studying the specific effect of  $\text{CO}_2$ , solutions of varying pH and  $\text{CO}_2$  pressures were prepared essentially according to the method of Smith & Clowes. To the freshly collected pond water, which was on an average 0.0005 N for "alkali reserve," sodium carbonate was added in different amounts to give six solutions: 0.0005 N, 0.0016 N, 0.0050 N, 0.0080 N, 0.0140 N, and 0.0250 N, respectively. To each of these alkaline solutions varying amounts of decinormal hydrochloric acid were added, and thus six pH ranges with different pressures of  $\text{CO}_2$  were obtained. It will be readily understood that at any pH in these ranges the maximum pressure of  $\text{CO}_2$  would be in the solution that was most alkaline originally, i.e., 0.0250 N solution, the others having less and less and the 0.0005 N solution the least.



The solutions were prepared in 140 cc. glass-stoppered bottles, into which the larvae were introduced immediately after adding the chemicals, after which the bottles were tightly closed so that no  $\text{CO}_2$  should leak out. In general the action of  $\text{CO}_2$  was that of a narcotic; at first the larvae were stimulated and showed great activity; then they appeared to be intoxicated and became almost motionless, their gills, however, still moving vigorously; ultimately the gills also stopped, when the individual was taken to be dead. The time for which the larvae lived in the various solutions was noted, but as will be explained at a later stage, a more reliable index of the influence of  $\text{CO}_2$  was afforded by the amount of oxygen that the larvae consumed under different conditions, which was measured by determining the amount that they left at their death. At the start, all the solutions had almost the same amount of oxygen, *i.e.*, about 7.0 cc. per litre (at N.T.P.).

To verify that the different ranges of pH did have varying amounts of  $\text{CO}_2$ , the solutions after the death of the individuals were titrated with N/44 soda, using phenolphthalein as an indicator, and the amount of  $\text{CO}_2$  was calculated according to the formula  $p \times 2.528 = \text{cc. of } \text{CO}_2 \text{ per litre}$ , where  $p = \text{no. of cubic centimetres of N/44 NaOH required for titrating 100 cc. of solution}$  (see Birge & Juday, 1911). The pH readings were also taken immediately after the death of the individuals. Owing to the addition of  $\text{CO}_2$  resulting from the respiration of the larvae, the amounts of  $\text{CO}_2$  and the pH values so determined would of course be slightly different from those at the start of the experiments, but on account of the small size of the individuals and the large size of the experimental bottles, this difference would be very small indeed. Further, the above method of measuring  $\text{CO}_2$  is not very up to date, but for the purpose of the present investigation, in which the relative rather than the actual concentrations of  $\text{CO}_2$  were to be determined, this method was quite convenient. McClendon's (1917) conversion tables or Saunders' formula (1926) for measuring  $\text{CO}_2$  pressures could not be used below pH 4.5–5.0 (when the alkali reserve cannot be determined), so they were not used at all.

The "alkali reserve" determinations were made by titrating the solutions with decinormal  $\text{H}_2\text{SO}_4$ , using methyl orange as an indicator.

### Effect of Carbon Dioxide.

The data obtained from the six solutions of varying  $\text{CO}_2$  pressure and pH are arranged in Tables I–VI and figure 1 (graph). Needless to say, far more extensive observations were taken than those mentioned in the tables. Each solution with its pH range differing by 1.0 was tried more than thrice.

As has already been explained, at any pH the greatest amount of  $\text{CO}_2$  will be in solution VI (0.0250 N), and the least in no. I (0.0005 N), the rest having intermediate amounts. An examination of the tables and curves will show that the pH remaining the same, the larvae also die quickest (or leave the greatest amount of oxygen) in solution VI and latest in solution I. For example, at pH 5.5–5.6, while in solution VI they lived for  $2\frac{1}{2}$  hours only, leaving 3.5 cc. per litre of oxygen, in solution V they lived for 44 hours, leaving 2.4 cc. per litre of oxygen, and so on. The curves for the various solutions (fig. 1), in which the abscissa represents the pH and the ordinate represents oxygen in cubic centimetres per litre left by the larvae at death, bring out this comparison very clearly. For instance, at pH 4.5 while in solution I the larvae live long enough to leave only 1.9 cc. oxygen per litre, in II–VI they leave 2.1, 2.5, 3.1, 4.0, and 5.5 cc. respectively.

As to the exact amount of  $\text{CO}_2$  that is harmful to the larvae, the tables and curves show that as long as the concentration of  $\text{CO}_2$  is 10.0–12.0 cc. per litre, the larvae go on living till they leave practically no oxygen (0.50–0.20 cc. per litre—a concentration below which they did not live under any condition in my experiments). When the concentration goes beyond 12.0 cc. the larvae begin dying quickly. Consequently the curves of the various solutions are almost straight till this concentration is reached,

after which they begin to rise steadily. And as this concentration is reached much earlier (at a higher pH) in solution 0.0250 N, its curve begins rising much sooner, at pH about 7.1, while in solution 0.0005 N it does not do so till pH 5.5.

As will be noticed from their shape, up till 100 cc. per litre  $\text{CO}_2$  concentration, the rate of rise of the curves (which means the time for which the larvae live) is more or less uniform, beyond this the curves begin to rise rather more rapidly.

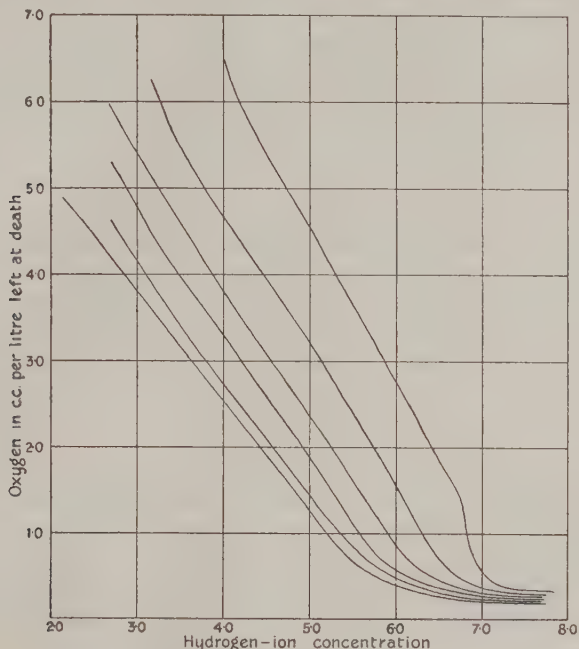


Fig. 1.

Thus, there is no doubt that  $\text{CO}_2$  apart from its hydrogen ions exerts a profound influence on the biology of the larvae. It is beyond the scope of this communication to discuss whether it does so on account of its greater power of penetration, as was suggested by Jacob and his co-workers, or on account of some other property.

### The Influence of Hydrogen Ion Concentration.

It does not require a long argument to show that the hydrogen ion concentration, as such, is also a factor of great importance. An examination of the tables will show that between pH 6.0 and 9.5 the larvae do not seem to suffer any harm due to the hydrogen ions; the most suitable pH seems to be about 7.0–7.5, when the larvae go on living till they utilise almost all the available oxygen, leaving only 0.20–0.50 cc. per litre, a concentration below which, as already alluded to, they cannot absorb oxygen at any pH. Further, it may be added that below pH 6.0 the larvae die more quickly than beyond pH 9.5. At pH 3.0 they die within eight hours. Jewell (1922) also noticed that Ephemerid larvae were absent in bottom waters, where acidity was rather high.

This seems to be a convenient stage when it may be explained why the amount of oxygen consumed affords a better index of the activity of the larvae than the time for which they live under different conditions. An examination of table I will

indicate that while at pH 7.2 the larvae live for 40 hours, at pH 5.9 they live for 72. If one were to rely on time alone one would conclude from this that pH 5.9 is more suitable than pH 7.2. But an inspection of the oxygen column shows that at pH 7.2 the larvae left only 0.30 cc. per litre of oxygen, while at pH 5.9 they died leaving as much as 1.60, which means that at pH 7.2 the larvae were flourishing so nicely that in 40 hours they consumed all the available oxygen and died for lack of it, while at pH 5.9 they obviously died from the action of the hydrogen ions and  $\text{CO}_2$ . Numerous similar instances can be quoted from other tables.

Incidentally the foregoing instances show how the hydrogen ion concentration governs the rate of oxygen consumption; at pH 7.2 in the above detailed instance, the larvae reduce the oxygen content to 0.30 cc. per litre in 40 hours, while at pH 5.9 they reduce it to 1.60 cc. in as many as 72 hours. This suggests that one way by which hydrogen ion exerts its harmful effect is by interfering with the respiratory function.

### Oxygen Requirements.

From what has been said above, it is evident that if pH and  $\text{CO}_2$  pressure are suitable, the larvae do not suffer from oxygen want until its concentration goes down as low as 0.20–0.30 cc. per litre.

Birge & Juday mention several animals, including insects, which do not seem to suffer for lack of oxygen till it is in extremely low concentrations. Recently Cole (1921) has also shown the same. Moreover, insects like *Chironomus* larvae are well known to be able to live in the entire absence of oxygen (Cole). Just recently the present writer has shown (1926) that some fishes also can stand a very low tension of oxygen.

### Conclusions and Summary.

Numerous experiments have been performed to study the specific effect of hydrogen ion concentration,  $\text{CO}_2$  and oxygen content of water on may-fly larvae, which warrant the following conclusions:—

1. While hydrogen ion concentration is a factor of great significance, the carbon dioxide pressure is of greater importance and should afford a very reliable index of the suitability of water as a habitat for true aquatic insects.
2. May-fly larvae, and presumably other insects as well, can stand a very low concentration of oxygen, below 1.0 cc. per litre. In view of the fact that in nature oxygen content seldom goes down to such a low figure, insects should not, as a rule, die of lack of oxygen.

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TABLE I.  
Solution 0.0005 N.

Dying time in hours.	Oxygen in cc. per litre left at death.	pH.	Co <sub>2</sub> content in cc. per litre.	Alkali reserve.
50	0.22	7.1	—	very little, not determined.
†4	0.25	7.0	2.5	"
36-48	0.30	6.4	7.5	"
25	0.65	5.5	11.0	"
9	2.90	3.7	20.5	"
4	4.40	2.5	30.0	"
2½	4.80	2.2	37.5	"

TABLE II.  
Solution 0.0016 N.

Dying time in hours.	Oxygen in cc. per litre left at death.	pH.	Co <sub>2</sub> content in cc. per litre.	Alkali reserve.
40	0.65	9.9	—	0.0015 N
150	0.50	9.4	—	0.0013 N
43	0.45	8.5	3.5	0.0011 N
125	0.22	7.75	3.7	0.0009 N
80	0.30	7.0	5.0	0.0008 N
68	0.30	6.6	9.5	0.0007 N
35	0.80	5.5	14.0	0.0002 N
15	3.40	3.5	25.0	—
8	4.60	2.5	45.5	—

\* Known to the writer in abstract only.

† Nymph almost fully grown.



TABLE III.  
Solution 0.0050 N.

Dying time in hours.	Oxygen in cc. per litre left at death.	pH.	Co <sub>2</sub> content in cc. per litre.	Alkali reserve.
20	1.3	10.0	—	0.0047 N
35	0.5	9.5	—	0.0030 N
19	0.3	7.7	—	0.0026 N
27	0.3	6.9	5.25	0.0022 N
48	0.4	6.4	12.25	0.0014 N
80	0.7	5.8	25.0	0.0009 N
40	1.6	5.2	37.5	0.0002 N
16	4.2	3.3	50.0	—
7	5.3	2.7	62.0	—
5	5.6	2.4	70.0	—

TABLE IV.  
Solution 0.0080 N.

Dying time in hours.	Oxygen in cc. per litre left at death.	pH.	Co <sub>2</sub> content in cc. per litre.	Alkali reserve.
12	2.80	10.2	—	0.0068 N
104	0.30	9.4	—	0.0043 N
30	0.30	7.1	8.5	0.0035 N
115	0.75	6.1	22.5	0.0015 N
34	1.00	5.9	27.5	0.0010 N
7	3.60	4.2	50.0	—
4	6.00	2.7	75.0	—

TABLE V.  
Solution 0.0140 N.

Dying time in hours.	Oxygen in cc. per litre left at death.	pH.	Co <sub>2</sub> content in cc. per litre.	Alkali reserve.
46	0.5	9.5	—	0.0083 N
40	0.3	7.2	4.25	0.0060 N
32	0.5	6.7	15.0	0.0045 N
72	1.6	5.9	32.5	0.0022 N
44	2.4	5.5	45.0	0.0010 N
4	4.5	4.1	70.0	—
3	6.2	3.2	100.0	—

TABLE VI.  
Solution 0.0250 N.

Dying time in hours.	Oxygen in cc. per litre left at death.	pH.	Co <sub>2</sub> content in cc. per litre.	Alkali reserve.
84	0.75	9.9	—	0.0190 N
114	0.56	9.6	—	0.0130 N
125	0.35	8.0	2.25	0.0110 N
120	0.35	7.6	7.5	0.0105 N
72	1.20	6.8	30.0	0.0088 N
8	2.30	6.25	50.0	0.0055 N
2.5	3.50	5.6	110.0	0.0015 N
1.5	4.60	5.0	138.0	0.0010 N
1	6.50	4.0	162.5	—

A NEW GENUS AND SPECIES OF CAPSIDAE (HETEROPTERA) FROM THE  
FLOWERS OF *COLA ACUMINATA* IN SIERRA LEONE. W.

By W. E. CHINA.

Genus **Torma**, nov.

Very small, shining black, evenly, but rather sparsely covered with very regular, equally long, pale, short, depressed hairs.

*Head* very strongly deflexed, including the eyes more than three times as broad as long, seen from above, but actually only a little more than one and a third times as broad as long seen in full face; seen from the side (fig. 2, a) shorter than height at base; frons and vertex moderately convexly arched, the vertex between the eyes about twice as wide as the diameter of one of the eyes (which are feebly prominent); basal margin of vertex between the eyes distinctly carinate, and slightly overlapping the anterior margin of pronotum; clypeus flat, not at all prominent, and obscurely delimited from the frons; rostrum extending to the hind coxae, the basal joint incrassate and reaching the base of the front coxae; antennae moderately short, inserted close to the front margin of the eyes at about two-thirds of the distance from the base of the eye to its anterior apex, first joint slightly incrassate, cylindrical,

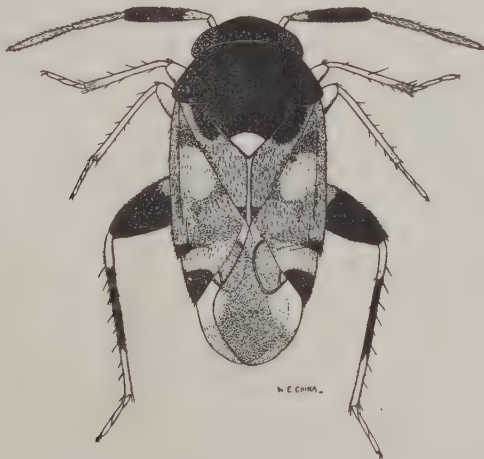


Fig. 1. *Torma colae*, gen. et sp. n.

extending to the apex of the clypeus, second joint incrassate more or less fusiform, the apex much thicker than the base, about three and a half times as long as the first joint, the third and fourth sub-equal, slightly thinner than, and about twice as long as, the first joint. *Pronotum* nearly three times as broad at base as long in middle, somewhat flattened, feebly convex, the sides straight and converging anteriorly, the basal margin very slightly, and very broadly emarginate, almost straight, no calli or pronotal collar present. *Scutellum* with sides equal in length to base, flat, the meso-scutum slightly swollen and uncovered by the posterior margin of the pronotum. *Hemelytra* with the membrane extending well beyond the apex of the abdomen, its hairs arising from minute punctures; embolium gradually widening from base to apex; large membrane cell short and broad, rounded at the apex. Hindwing-cell without a hamus. Metasternal orifices with well-developed posteriorly directed auriculate lobes. *Legs*: hind femora (fig. 2, b) strongly incrassate as in *Halticus*,

the hind tibiae with two rows of distinct spine-like bristles, the hind tarsi (fig. 2, *c*) linear, the second joint longer than the third; claws (fig. 2, *d*) very short, sub-parallel, feebly divergent, provided with large pseudoarolia extending beyond the middle of the claws, and two bristle-like arolia.

Genotype *Torma colae*, sp. nov.

In general appearance, especially in the shape of the vertex and pronotum, strongly resembling the genus *Halticus*, Hahn., in which, however, the claws are widely divergent with well developed membranous divergent arolia and the antennae are very long and filamentous. The structure of the claws and arolia is typical of the PHYLINAE, but the absence of a hindwing-cell hamus decides the relationship with the HETEROTOMINAE. *Torma* is one of those genera which break down the value of

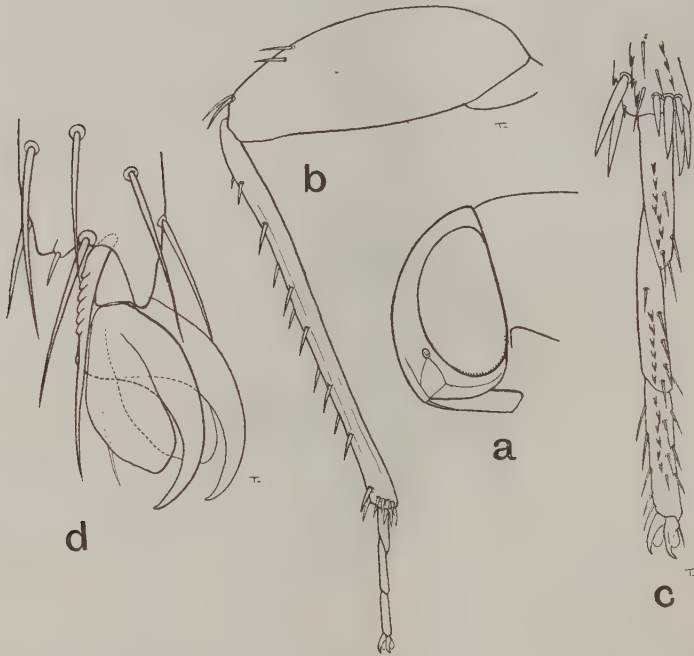


Fig. 2. *Torma colae*, gen. et. sp. n.: a, side view of head; b, hind leg, showing armature but not pilosity; c, hind tarsus; d, hind tarsal claws, showing arolia and pseudo-arolia.

the structure of the claws and arolia as a subfamily character in the CAPSIDAE. As more and more tropical genera become known, it will probably be found that these organs are too plastic to serve as a fundamental subfamily character, and there is no doubt that Reuter and Poppius have exaggerated their value as a guide to relationships of Capsid genera.

#### ***Torma colae*, sp. nov. (fig. 1).**

♂, ♀. *Head* shining black, unpunctured, sparsely covered with very short, pale, depressed hairs; rostrum pale ochraceous, with the basal joint and the extreme apex dark brown; antennae pale ochraceous, with the second joint (except its base) dark brown or black; length of joints 8, 28, 17, 17 (63 = 1 mm.). *Pronotum*, basal two-thirds of scutellum, and the pro- meso- and metapleura shining black; the pro-

notum and scutellum sparsely covered with very regular, short pale depressed hairs, visible only at moderate magnification ( $\times 15$ ); apex of scutellum yellowish white; lobe of odoriferous orifice and evaporative area dull black. *Hemelytra* more or less hyaline, a large elongate spot at base of clavus along edge of scutellum, the apices of the clavus and embolium, and the apical half of the cuneus dark brown or black; corium more or less marked with brown suffusions, but with a whitish hyaline area on the disc; basal half of cuneus also whitish hyaline; membrane infusate, with a colourless area below the apex of the cuneus. *Abdomen* shining black, with rather long pale hairs, the basal two-thirds of the disc of the venter pale ochraceous. *Legs* pale ochraceous, the apical two-thirds of the hind femora and a wide annulation in the middle of the hind tibiae dark brown or shining black; the hind femora with a few long, fine bristles on the underside, the spines of the hind tibiae brown; the intermediate femora with a row of long pale bristles along the inner edge.

*Total length*, 1.8 mm. ; breadth across base of pronotum, 0.67 mm.

SIERRA LEONE: Torma, 4 ♂♂, 5 ♀♀ on kola flowers (*Cola acuminata*), 27. viii. 1926 (E. Hargreaves).





# R. NEW FLEAS FROM SOUTH AFRICAN RODENTS.

By Dr. A. INGRAM, W.

*South African Institute for Medical Research.*

During the carrying out of field work in connection with the investigation of plague in the Union of South Africa, certain fleas which appeared to be new were taken in the nests of water rats and on a golden rock mouse in the Karroo.

Whilst resembling *Chiastopsylla*, Rosthsch., morphologically, the fleas from the Karroo rats differ from that genus in the absence of tooth-like spines at the genal margin of the head, and the flea taken on the rock mouse differs in possessing no pronotal comb, in addition to the absence of spines at the genal margin of the head. It was thought that these differences would require the erection of new genera for the reception of these fleas; two specimens, however, of one of the species showed an incomplete set of genal spines, and Dr. Jordan, who kindly examined the material, considers that all the fleas described below belong to the genus *Chiastopsylla*. Apparently, if one may judge from the presence of genal spines in the two specimens found, certain species of this genus have been recently evolved.

I have to express my indebtedness to Dr. G. A. K. Marshall for much help rendered and for obtaining the opinion of Dr. Jordan as to the generic position of the fleas; my thanks are also due to Dr. Jordan for his kindly criticism and for so generously providing drawings to illustrate the descriptions of the fleas.

## *Chiastopsylla pitchfordi*, sp. nov.

*Head* evenly rounded in the female; in the male there is a trace of a notch on the frons. Bristles and hairs similar to those of *Ch. rossi*, Waterst.; a row of hairs between the antennal groove and the maxillary palps immediately in front of the eye, and two bristles behind and parallel with this row. A long bristle just above the eye and three bristles behind the antennal groove, which has a row of fine hairs along its posterior margin. A stout bristle and a row of hairs along the posterior margin of the occiput. The hairs on the first and second segments of the antenna very short. The relative lengths of the segments of the maxillary palps are 20, 21, 16, 26. The genal spines absent as a rule.

*Thorax*: the pronotum has a row of 12 bristles in front of the comb, which consists of 12 teeth. The mesonotum bears a row of fine hairs at the base, a median row of 8–10 hairs (4–6 in the male) and a posterior row of 10–12 bristles. The metanotum has an antemedian row of 8–10 hairs (2 or 3 in the male), a posterior row of 12 bristles and two teeth on each side of the median line at its distal edge. The metathoracic epimeron carries 2 or 3 bristles in the anterior and 2 or 3 in the posterior row.

*Legs*: the hind tibiae without any accessory bristles between the paired bristles on their dorsal margins. Three or four bristles in a row on the outer side of the hind tibiae. The relative lengths of the tarsal segments are as follows:—

	I.		II.		III.		IV.		V.
Foreleg	10	...	12	...	10	...	9	...	25
Midleg ...	20	...	23	...	16	...	13	...	24
Hindleg	50	...	35	...	23	...	16	...	30

*Abdomen*: two rows of bristles on the tergites of the first seven segments and one row on the sternites of segments ii to vii. In the female there are usually no teeth at the distal margins of the proximal tergites, but the male has two on the first three

tergites. The following table gives the number of hairs or bristles on the various segments of the abdomen in the male and female :—

*Male.*

Tergites	I.	II.	III.	IV.	V.	VI.	VII.
Antemedian row	6 ...	2-4 ...	2 ...	4 ...	4 ...	2-3 ...	2-3
Postmedian row	10 ...	14 ...	13 ...	13 ...	12 ...	12 ...	11
Teeth	2 ...	2 ...	2 ...	— ...	— ...	— ...	—
Sternites	— ...	2 ...	6 ...	4 ...	4 ...	4 ...	6

*Female.*

Tergites	I.	II.	III.	IV.	V.	VI.	VII.
Antemedian row	6-8 ...	6-8 ...	5-6 ...	6 ...	7 ...	4 ...	4
Postmedian row	10-11 ...	13 ...	13 ...	13 ...	13-14 ...	12 ...	11
Teeth	0-2 ...	— ...	— ...	— ...	— ...	— ...	—
Sternites	— ...	2 ...	8 ...	6 ...	6 ...	8 ...	9

The antepygidial bristle single and as long as the second hind tarsal segment. The stylet slender and barely three times as long as broad.

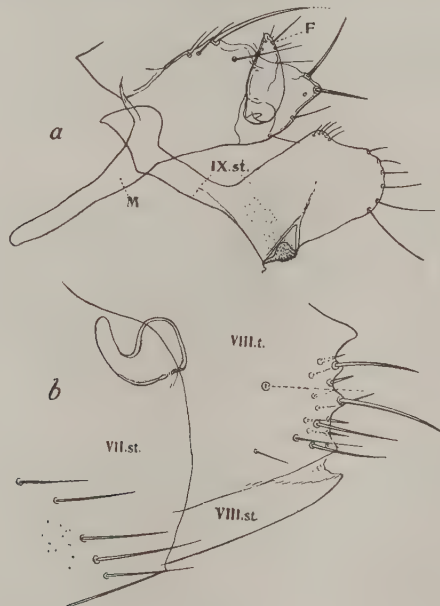


Fig. 1. Terminal segments of *Chiastopsylla pitchfordi*, sp. n.: a, male; b, female.

*Modified Segments.* Male (fig. 1, a): the "finger" (F) is conical in shape and bears two or three short hairs at its apex; two longer hairs on its distal margin with a short one between them; one or two fine hairs also occur on the proximal margin. The clasper is ovoid or leaf-like in shape and carries a long bristle before its middle and two shorter ones at its distal edge; there are also a few hairs along its dorsal edge; the manubrium tapers slightly to a blunt extremity. The vertical limb of the ninth sternite narrow and more highly chitinised than the horizontal limb, which is broad and

spatulate, bearing a fringe of curved hairs along its apex. The genitalia bear a very close resemblance to those of *Ch. godfreyi*, Waterst. (Proc. Roy. Phys. Soc. Edin., xix, p. 10, fig.) ; the internal plate of the penis is, however, considerably longer than the manubrium, whereas Waterston states that the internal plate is shorter than the manubrium in *Ch. godfreyi*.

Female (fig. 1, *b*) : the eighth tergite is sinuous at its distal margin and carries four or five bristles on its lateral aspect and two at the apical margin, the bristles of the inner surface short. The seventh sternite has an evenly rounded posterior border, showing no sinus.

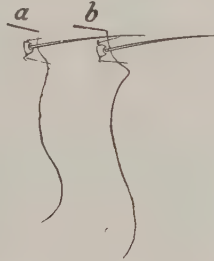


Fig. 2. Seventh tergite of (a) *Chiastopsylla mulleri*, sp. n., and (b) *Ch. pitchfordi*, sp. n.

In the male of this species, as in *Ch. godfreyi*, the first and second hind tarsal segments have very long apical bristles, which exceed in length the combined length of the three segments distal to the one on which they are situated.

Length : male, 1.6 mm. ; female, 2 mm.

Several specimens of both sexes collected in the nests of the Eastern Karroo rat (*Parotomys luteolus*) at Steynsburg, Cape Province, in October 1925.

The species is named in honour of the Director of the South African Institute for Medical Research, Dr. W. Watkins-Pitchford.

### ***Chiastopsylla mulleri*, sp. nov.**

The females of this species are difficult to distinguish from those of the previously described species, but the males may readily be separated by the curved tuft of bristles on the eighth abdominal sternite.

*Head* evenly rounded and somewhat more abruptly curved than that of *Ch. pitchfordi*. Eye well developed. Hairs and bristles on frons and occiput situated as in *Ch. rossi*. Rostrum slightly shorter than the maxillary palps but reaching to the trochanter of the foreleg. The genal spines are absent.

*Thorax and Abdomen* : the hairs and bristles similar to those of *pitchfordi*. Two teeth in both sexes at the distal margin of the metanotum on each side of the middle line, and in addition in the male usually a single tooth on each side on the first three abdominal tergites.

*Legs* : the bristles on the first two hind tarsal segments of the male shorter than those of *pitchfordi*, the longest bristle of the first hind tarsal reaching to the apex or slightly beyond the apex of the second, the longest bristle of the second hind tarsal segment reaching to the apex or slightly beyond the apex of the fourth.

*Modified Segments* : the eighth sternite of the male has a subapical ventral tuft of five to seven dorsally curved bristles with one or more straight ones. The clasper is shaped much as is that of *pitchfordi* but is narrower distally, and the single stout spine at its apex is shorter. The "finger" is not so conical as in *pitchfordi*, the



proximal margin being straighter; the manubrium shorter and broader than in that species. The vertical (outer) arm of the ninth sternite (fig. 3) is more triangular in



Fig. 3. Ninth sternite of *Chias topsylla mulleri*, sp. n., ♂.

shape than that of *pitchfordi* and carries a tuft of four to five dorsally curved bristles at the junction of its ventral and distal margins; there are also one or two short bristles, which are not found in *pitchfordi*, on its lateral surface. The seventh tergite of the female has a much less prominent hump at its distal margin external to the antepygial bristle than the similar tergite of *pitchfordi* (fig. 2, a, b).

*Length*: male, 1.5 mm.; female, 2 mm.

Numerous males and females collected in the nests of Karroo rats (*Mystomys broomi*, Thos.) at Calvinia, Cape Province, in July and August, 1926, by Mr. T. Muller, after whom the species is named.

There seems to be some variation in the length of the longest bristles of the first and second hind tarsal segments of the males of this species. In a small collection numbering 4 males and 25 females, obtained by Mr. Muller in the nests of Karroo rats at Zak River in August, the females are indistinguishable from those taken at Calvinia, but all the males have long bristles on the first and second hind tarsal segments. As there is little, if any, difference in the genitalia of the males taken at Calvinia and at Zak River, it seems advisable to regard the fleas taken at the latter place as a variety of *P. mulleri*. This variety may be defined as follows:—

#### ***Chias topsylla mulleri* var. *longisetis*, nov.**

Females indistinguishable from those of *P. mulleri*. Males with the longest bristle on the first hind tarsal segment reaching to three-fourths the length of the fifth segment, and with the longest bristle on the second hind tarsal segment reaching to the apex of the fifth segment.

*Modified Segments*: the curved subapical ventral bristles on the eighth sternite of the male do not form so distinct a tuft as in *mulleri*, being more equally spaced along the margin of the sternite.

*Length*: male, 1.5 mm.; female, 2 mm.

Taken in the nests of Karroo rats (*Mystomys broomi*) at Zak River, 60 miles north of Calvinia, in August, by Mr. T. Muller.

#### ***Praopsylla*, gen. nov.**

Closely resembles the genus *Chias topsylla*, but is devoid of a pronotal comb and of tooth-like spines at the genal angle of the head.

The head is evenly rounded, with a trace of a frontal tubercle. Genal angle of the head not produced into a lobe and the genal spines absent. Labial palps of four segments. Eye vestigial, not pigmented. Club of the antenna segmented all round. A single row of bristles between the eye and the maxillary palps. Abdominal tergites with one row of bristles. Hind coxa with a row of minute spines on its inner surface.

Fifth tarsal segment of all legs with four spines and the usual subapical bristle on each side, and with two ventral spines apically, but no ventral spines proximally between the first lateral pairs.

***Praopsylla powelli*, sp. nov.**

♀. *Head* evenly rounded, with a row of three stout bristles between the eye and the maxillary palps. Three bristles above the antennal groove, but no subapical row of hairs on the occiput. Rostrum very long, half as long again as the maxillary palps and reaching well beyond the trochanter of the foreleg.

*Thorax*: pronotum with a postmedian row of eight bristles on the two sides together, the outermost bristle on each side being stouter and more widely separated than the rest. Mesonotum with a postmedian row of eight bristles. Metanotum with a postmedian row of eight bristles. Metepimeron with a single bristle, besides a small one behind the stigma.

*Legs*: forecoxa with about 14 bristles on its outer surface. First mid-tarsal segment half as long again as the second. Hind coxa with about a dozen bristles on the outer side and a row of five or six short spines on the inner side. Hind femur with two ventral subapical bristles, hind tibia without hairs on the outer surface. Bristles on the hind tarsal segments short, the longest bristle on the second hind tarsal reaching just beyond the apex of the third.

*Abdomen*: the tergites carry only a single row of bristles; the number of bristles on the various segments is given in the following table:—

	I.	II.	III.	IV.	V.	VI.	VII.
Tergites ...	8-10	10	11	10	10	8	6
Sternites ...	—	2	6	4	4	4	8

Antepygidial bristle single with two minute hairs at its base; it is as long as the second hind tarsal segment. The eighth tergite overhangs the pygidium. The stylet slender and about four times as long as wide. The spermatheca resembles that of *Ch. rossi* in shape, its tail being longer than its head.



Fig. 4. Eighth tergite of *Praopsylla powelli*, sp. n., ♀.

*Modified Segments*: the seventh sternite has an evenly rounded distal margin, the eighth tergite is sinuous along its distal edge (fig. 4) and bears a single bristle laterally and about sixteen bristles close to the distal margin. The anal segment carries three or four stout bristles.

*Length*: female, 1.6 mm.

Two females taken on a golden rock mouse (*Praomys arborarius*, Ptrs.) by Mr. W. Powell, after whom the species is named, at Lickerroog, Calvinia District, Cape Province, 1.vii.1926.



# SOME INSECTS ASSOCIATED WITH COTTON IN PAPUA AND THE MANDATED TERRITORY OF NEW GUINEA. (10)

By E. BALLARD, B.A., F.E.S.,  
*Commonwealth Cotton Entomologist.*

(MAP.)

In the following paper is given a list of cotton pests of Papua and New Guinea, with some notes on distribution and behaviour. The list makes no pretensions to being complete, but might prove useful in the event of cotton-growing being extended in that region.

In August 1925, instructions were received to accompany Mr. G. Evans, C.I.E., then Director of Cotton Culture to the Queensland Government, on a tour of cotton areas potential and actual in Papua and the Mandated Territory of New Guinea.

We sailed from Brisbane on 13th August and returned on 30th October. Of the short time at our disposal some 40 odd days were spent at sea. In consequence, the time available for collecting entomological material was not as much as might have been desired.

Nearly all the areas actually under cotton in Papua were visited, with the exception of one or two places that were inaccessible owing to poor landing facilities or rough weather. The route followed is shown in the accompanying map, which is taken from Mr. Evans' report on the same tour.

Collections were made at places where we anchored for the night or were driven for shelter from the weather, and also in the vicinity of Rabaul and on the march up the Markham Valley. As a rule attention was paid chiefly to Malvaceae and allied plants and to cotton fields.

In Papua cotton-growing is confined to the so-called dry-belt running 40 miles east and west of Port Moresby. There is also an experimental plot of Egyptian cotton on the east coast some 30 miles inland at Sangara, which time did not permit us to visit. In the Mandated Territory, except for a few scattered plants of Kidney cotton and the experimental plots up the Markham Valley and near Rabaul, there is no cotton grown on a commercial scale. The island of Kar Kar had a considerable area under Kidney cotton, but this is now, I understand, given up.

Mr. G. Evans has given a full account of the cotton-growing areas in his report published in the *Empire Cotton Growing Review* for July 1926.

Papua showed nothing very unusual in respect of the various pests afflicting the cotton. The most interesting point was the presence of *Platyedra gossypiella*, which on the coastal plantations and in the vicinity of the ginneries at Port Moresby was well established. It was found also in a solitary bush of Kidney cotton which must have been of considerable age, some six miles from the nearest plantation. Capsules of the strand-loving *Hibiscus tiliaceus* yielded only one specimen, which will be referred to hereafter, although in the vicinity of fields heavily infested. Damage typical of that done by *Platyedra* was seen in some cases in capsules of *H. tiliaceus*, but in the absence of the larva itself this can hardly be treated as evidence.

At Tavai, some 30 miles south-east of Port Moresby, and on the coast, *Hibiscus* spp. were thoroughly infested. At this place there was a proportion of the Queensland variety of *P. gossypiella*, recently named *P. scutigera* by Mr. F. G. Holdaway, who regards it as a separate species. The seed for this plantation had been imported from Queensland before the institution of treatment of cotton seed by heat, and it is more than probable that *P. scutigera* had been carried from Queensland in this way. One specimen was secured from a capsule of *H. tiliaceus* that was near the ginnery at Tavai,



but it might easily have come from moths flying from the cotton lying in the ginnery. (*Abutilon indicum* at Port Moresby close by the ginnery was infested with *P. gossypiella*, but plants a mile or two away were quite free from it.)

The infestation of the cotton fields was as heavy as any I have ever seen and was a fine example of the unwisdom of growing cotton as a perennial in the presence of pink bollworm.

Investigation into the history of cotton-growing in Papua shed no light on the source from which *P. gossypiella* had come, unless it were from Fiji. It was unfortunate that we could not go further west to see how far *P. gossypiella* was spread along the coast. It has been recorded from the Kei Islands, but does not appear to have been found anywhere in the Dutch East Indies or in the Malay Archipelago. Cotton in Rabaul showed a very high percentage of attack, but the German records make no mention of *P. gossypiella* up to 1912 in New Guinea or in any of the islands in the vicinity. A plot of cotton of some 25 or 30 acres in extent and some 10 or 15 miles from the coast just out of the dry belt showed no signs of infestation, nor did the cotton from Sangara on the east coast. After leaving Tavai and going east no pink bollworm was seen anywhere along the coast either in *Hibiscus* or *Thespesia*.

The most obvious source of infestation would appear to be Queensland; but although Queensland seed had been purchased fairly recently, there was only one place, of those in which the Queensland pink bollworm could be found, where no seed had been brought from anywhere else. There, it was in a minority compared with the typical *P. gossypiella*, which is not seen in Queensland, although it abounds in the Northern Territory. It is possible that *P. gossypiella* is indigenous to Papua, but this appears improbable, and to settle the point careful search would have to be made to the west.

Of other bollworms, *Earias fabia*, Cram., was the most common. In the Markham Valley a cotton plot seven miles from the nearest Malvaceae likely to shelter *Earias* was suffering some damage from the larvae of a species of *Earias* with which I was unfamiliar. I was unable to breed the moth from any of these owing to our being continuously on the march.

Both in Papua and at Rabaul a species of Jassid (*Empoasca*) was responsible for considerable damage to cotton crops. At Rabaul and in its vicinity this damage was most marked, worse than anything I have seen before. In Papua the potash-deficient soils suffered most, but this raises questions which it is not intended to discuss in the present paper. It will suffice to say that although the Rabaul soil showed no deficiency (or only a slight one of phosphoric acid), there was some other factor present which inhibited root development, as the tap-roots only penetrated a short way into the soil and then turned and grew in a horizontal direction. There was no question of a pan, as there was apparently an unlimited depth of soil. It might possibly be due to deficient drainage. At Tavai, in Papua, there was no sign of Jassid damage.

Thrips were common on the old stray cotton bushes found in New Guinea, two species being present.

Stainers, *Dysdercus cingulatus*, spotted and banded forms, were abundant everywhere except on the experimental plot of Durango cotton 50-60 miles inland up the Markham Valley. An attempt had been made by a native in this Valley some 9 or 10 miles further on to plant cotton of a variety unknown but probably a Kidney cotton hybrid. About 200 yards away a tree (*Eriodendron malabaricum*) was swarming with *Dysdercus cingulatus* (spotted variety). None was to be found on the cotton, which indeed was most extraordinarily free from insect pests.

*Tectocoris lineola* was fairly common in Papua and Rabaul, but had hardly achieved the status of a pest of the first order. It displayed very little signs of the wonderful variety of colour seen in Queensland. One blue male was captured in Papua, but all the other specimens were dull yellow. It would be interesting to know whether this

coloration is due to climatic influences, as the deepest colouring is seen in Queensland in spring and autumn. The Germans listed it as a cotton pest.

*Oxycaenus* was rare in New Guinea but abundant in Papua. This species, I am informed, is new and at the time of writing not described.

I saw no leaf-eating caterpillars, but before my arrival these had done a great deal of damage in some plantations in Papua. From the descriptions given me they were either *Prodenia litura* or *Heliothis obsoleta*. *H. obsoleta* was found in Cape gooseberry and *Abutilon indicum* in Papua, and in maize near Rabaul. Curiously enough, none was seen in maize in the Markham Valley. *Conogethes punctiferalis*, a severe pest of late-planted cotton in Queensland, was found in the Markham Valley on a castor plant, but nowhere on cotton.

Scales and mealy-bugs were found only on cotton that was already weakened from other causes. This conforms with one's experience of cotton in other countries.

A weevil, *Apirocalus cornutus*, was very common on cotton and other Malvaceae, eating the leaves. Another weevil, *Amorphoidea bicolor* was abundant in cotton flowers as a pollen-feeder, often associated with a Nitidulid beetle, *Haptoncus concolor*, in this capacity. These pollen-feeding beetles rarely cause any real damage.

So far as such a hurried inspection could allow conclusions to be drawn, the most important pests would appear to be *P. gossypiella* and species of *Dysdercus*.

The banded form of *D. cingulatus* seemed to persist more in the areas of heavy rainfall, the drier areas having only the spotted variety bearing a superficial resemblance to *D. sidae*. They existed together in certain places. In the Markham Valley, at the point where the wet belt ceases abruptly and the rain shadow area begins, both varieties exist, but further inland, where there is apparently a much smaller rainfall, only the spotted form was found. *D. papuensis* was taken on bushes of Caravonica cotton on Goodenough Island, but was not found on any of the plantations near Port Moresby.

The general climatic conditions, even in the dry belt of Papua, would favour the increase of internal boll rots, and cotton both there and in New Guinea would probably suffer from these diseases more than from any other.

Jassids had done some damage, but this appeared to be the result of cotton being grown on unsuitable soil.

# *A List of Insects found on Cotton and related Plants in Papua, New Guinea, and the Islands.*

## Order LEPIDOPTERA.

### Family GELECHIIDAE.

*Platyedra gossypiella*, Saunders. Papua. Appears to be limited to the coast. The distribution west of Cape Suckling is not known. East it was found as far as Tavai. In the Mandated Territory it was a severe pest in Rabaul. The Queensland variety, *P. scutigera*, Holdaway, was found only at Tavai, and here it was in a minority to *P. gossypiella*.

### Family NOCTUIDAE.

*Earias fabia*, Cram. Common in Papua. In the Markham Valley a species of *Earias* was damaging Durango cotton, but no moths were secured.

*Heliothis obsoleta*, F. Papua and New Britain ; not seen in New Guinea.

## Family PYRALIDAE.

*Conogethes punctiferalis*, Gn. New Guinea, on castor. A larva of similar appearance but much more pink in colour was found in a seed-capsule of *Hibiscus tiliaceus* on Goodenough Island and also in Argyll Bay, but the moth could not be bred.

*Sylepta* (?) *derogata*, F. Leaf-roller of cotton seen in one plantation in Papua.

## Order COLEOPTERA.

## Family NITIDULIDAE.

*Haptoncus concolor*, Murray. In cotton flowers, Papua.

## Family LAMIIDAE.

*Glenea hygia*, Thoms. On *Hibiscus* sp.

## Family CURCULIONIDAE.

*Apiocalus cornutus*, Pasc. Very common in Papua and New Guinea inland up to 950 feet and on the coast, on cotton and allied genera.

*Coptorrhynchus cruciatus*, Fst.

*Coptorrhynchus* sp.

*Platyachus* sp. On cotton leaves.

*Rhinoscapa schmeltzi*, Fairm. On cotton leaves.

*Amorphoidea bicolor*, Fst. On cotton flowers.

## Family EUMOLPIDAE.

*Rhyparida coricaea*, Jac. Lac, east coast of New Guinea. Doing considerable damage to cotton leaves.

## Family GALERUCIDAE.

*Monolepta rosea*, Blkb. Sometimes a severe pest of cotton in Queensland and New South Wales. One specimen was secured in Papua (Rorona) on cotton.

## Family BRENTHIDAE.

*Miolispa novaeguineensis*, Guér. Goodenough Island.

*Uropterodes gestroi*, Senna. Markham Valley, New Guinea.

## Order RHYNCHOTA.

## Family PENTATOMIDAE.

*Aspideurus flavescens*, Bredd. Papua. On cotton.

*Antestia semiviridis*, Wlk. Papua. On cotton.

*Glaucias* sp. Rabaul. On *Hibiscus sabdariffa*.

*Tectocoris lineola*, F. Papua and New Britain.

## Family LYGAEIDAE.

*Dieuches* sp.

*Lygaeus hospes*, F. On cotton.

*Oxycarenus* sp. Very scarce in New Guinea. Not present on cotton in Rabaul.

## Family PYRRHOCORIDAE.

*Dysdercus cingulatus*, F. Two forms ; one spotted, which appeared to be confined more to the drier regions such as the Markham Valley from 30 miles inland, and the banded form. The latter predominated or occurred alone on those portions of the coast where a humid climate prevailed.



*D. variegatus*, Dist., was taken associated with these two varieties at Gabsonkek, in the Markham Valley, just at the boundary of the drier area.

*D. papuensis*, Dist. Papua and New Guinea on the coast, on *Hibiscus*; on the islands, from an old cotton bush on Goodenough Island; and from *Hibiscus* and *Bombyx* on Long Island (Arop). Nymphs in the last-named locality, where the dry season was in progress, were seen indulging in cannibalism. This has been observed in *D. sidae*, Montr., in similar circumstances in Queensland. Although large numbers of these three species of *Dysdercus* were collected, *D. sidae* was not found.

*Dindymus pyrochrous*, Boisd. Markham Valley, New Guinea. Predacious on *Dysdercus cingulatus*; but it does not feed exclusively on this insect.

*Hyalopeplus* sp.

Family CAPSIDAE.

*Euphanta* sp.

Family FLATIDAE.

*Terentius nubifasciatus*, Wlk.

Family MEMBRACIDAE.

*Tetragoniella candida*, Wlk.

Family JASSIDAE.

On cotton, but not really doing serious injury.

*Empoasca* sp. Doing severe damage in parts of Papua and in Rabaul and the neighbourhood, where the loss occasioned by it was considerable.

Family APHIDAE.

*Aphis gossypii*, Glover. General.

Family COCCIDAE.

*Saissetia nigra*, Nietn. New Britain and Papua.

*Fenisia virgata*, CKL. New Britain and Papua.

Both the species were taken on cotton damaged by other factors.

Family PSYLLIDAE.

*Mesohomotoma hibisci*, Frogg. On *Hibiscus*, on Long Island, Bismarck Archipelago, and at Hula, Papua.

Order THYSANOPTERA.

Family THIRIPIDAE.

*Heliothrips haemorrhoidalis*, Bch. On cotton; New Guinea.

*Liothrips* sp. n. ? Papua.

These species appeared to be doing some damage to the green bolls of Kidney cotton but were not very serious pests. It is possible that they might become a source of trouble, but probably only to unhealthy cotton.

Dr. Aulmann (Die Fauna der deutschen Kolonien, Reihe V, Heft 4. Die Schädlinge der Baumwolle. Berlin, 1912) gives a list of insects taken on cotton in New Guinea, the Bismarcks, etc., but does not mention Jassids, or *Platyedra gossypella*. He mentions no species of *Earias* as a pest of cotton in New Guinea, but gives *E. fabia* and *E. insulana* as being found in Australia; *E. insulana*, however, does not occur in Australia. His list is given below:—

DYNASTIDAE: *Pimelopus tenuistriatus*, Aulm. New Britain.

MORDELLIDAE: *Mordella leucospila*, Fairm. Bismarcks.

TELEPHORIDAE: *Telephorus varicornis*, Fairm. Bismarcks.



COCCINELLIDAE : *Harmonica 8-maculata*, F. Bismarcks.

CERAMBYCIDAE : *Aeolesthes ampliata*, Gahan. New Britain.

ANTHRIBIDAE : *Phloeops platypennis*, Montr. Bismarcks.

NOCTUIDAE : *Heliothis obsoleta*, F., *Cosmophila flava*, F. (*erosa*, auct.), *Prodenia litura*, F., *Sylepta derogata*, F.

APHIDAE : *Aphis gossypii*, Glover.

PENTATOMIDAE : *Tectocoris lineola*, F.

PYRRHOCORIDAE : *Dysdercus cingulatus*, F., *D. sidae*, Montr. (the latter is possibly the spotted form of *D. cingulatus*).

*Acknowledgements.*

I am indebted to the Imperial Bureau of Entomology for the identification of the insects in the foregoing list.

I wish also to acknowledge the assistance given by the Hon. Stanniforth Smith, O.B.E., Director of Agriculture, Papua, and Dr. G. Bryce, lately Director of Agriculture in New Guinea, and to thank them for all the arrangements made for our tour. Also to express my thanks to Mr. G. A. Loudon, of Port Moresby, and his plantation managers for hospitality and arrangements made when visiting their plantations.

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# AN IMPORTANT PARASITE OF THE GREENHOUSE WHITE-FLY (*TRIALEURODES VAPORARIORUM*, WESTWOOD). W.

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(PLATES XXIII-XXV.)

## Introduction.

The greenhouse white-fly, a Homopterous insect well known as a persistent pest to every grower of plants under glass, has been kept under fairly close observation for years past by Economic Entomologists, and has also received some attention at the hands of Geneticists, in both Europe and the United States of America. Records of natural enemies and diseases of the insect are, however, rare; two fungous parasites, *Cephalosporium lefroyi* and a species of *Cladosporium*, were alluded to by A. S. Horne in 1915,<sup>5</sup> and the only insect enemies so far found belong to the CHALCIDIDAE. Further, these insect parasites are confined to the genus *Encarsia*, and only three species are known to parasitise the scale-stages of white-fly.

*Encarsia versicolor*, Gir., was recorded from glasshouses in Michigan, U.S.A., in 1924 by E. I. MacDonald,<sup>8</sup> who says (p. 39) "a tiny hymenopter attacks the nymphs of the white-fly, sometimes completely clearing up the infestation."

*Encarsia pergandiella*, How., is stated by Garman & Jewett<sup>3</sup> to oviposit in late larvae and pupae, but is not sufficiently numerous to act as an effective check on white-fly in Kentucky, U.S.A. (1922).

*Encarsia formosa*, Gahan, was described by A. B. Gahan<sup>1</sup> from specimens collected in Ohio, U.S.A., in 1924, and was found parasitising the pupae of white-fly in a greenhouse.

Other species of *Encarsia* parasitising various ALEURODIDAE have been recorded from Nigeria, Eritrea, and Barbados.

## Occurrence of *Encarsia* in Great Britain.

In England an *Encarsia* has twice been recorded as parasitising white-fly in glass-houses by Mr. G. Fox-Wilson, Entomologist to the Royal Horticultural Society, who kindly drew attention to its previous occurrences and has taken much trouble in going through correspondence upon the subject.

In a letter dated 20th August 1926, Mr. Fox-Wilson writes the following:—"This Chalcid was bred out in large numbers in a tomato house at Wisley (Surrey) in 1914-15 (*vide* "Gardeners' Chronicle," Vol. lviii, 4th September 1915, p. 154) and was sent out to nurserymen in various parts of the country. On the departure of Prof. Lefroy and myself from Wisley in 1915 for military duties, the parasite died out through lack of food, for the tomato house was completely cleared of white-fly by means of its efforts. In October 1921 I found this parasite\* attacking nymphs of white-fly on fuchsias in a greenhouse at Cobham (Surrey) and sent material to Prof. Lefroy, who acknowledged its safe arrival in a letter dated 26th October 1921, saying that he was recommending the breeding of it under controlled conditions."

The article referred to in the "Gardeners' Chronicle"<sup>6</sup> is signed "H. M. Lefroy" and contains no information further than that given by Mr. Fox-Wilson. Unfortunately, material of these two occurrences cannot now be traced, and in neither case does the species appear to have been identified.

\* At the time of writing it was presumed that the species was *E. formosa*, Gahan, but it is probable that this was a different species of *Encarsia*, at least in the case of the 1914 record.



At Wisley on some tomato plants that had been grown in the glasshouses where the parasite originally appeared in 1914 and that were moved outside at the end of August, numerous parasitised pupae of white-fly, together with male and female adults of an *Encarsia*\* obviously differing from *E. formosa*, were found on 26th September 1926. Pupal cases of white-fly from which this parasite had emerged were present in the glasshouse from which these plants had been removed. This parasite awaits identification, and it is very probable that this *Encarsia* did not die out as originally supposed and is of the same species as that first recorded in 1914.

Letters from nurserymen to whom the parasite was sent in 1914 and 1915 do not attest to the establishment of this species, but there can be no doubt that the distribution was effected in a very haphazard way.

On 2nd July 1926 the Experimental Station at Cheshunt received some tomato leaves from the Editor of the "Gardeners' Chronicle" with a letter from Mr. L. Hawkins, Deacon's Court, Elstree, Herts, pointing out that some of the white-fly scales on the leaves had turned black, and asking the nature of the parasite that had attacked the scales. Soon after receipt Chalcids emerged from the black pupae, and were sent to the British Museum (Natural History) for identification. On 7th August our reply to Mr. Hawkins appeared in the "Gardeners' Chronicle" (p. 120).

In a letter dated 2nd August 1926 Dr. J. Waterston states: "Your parasite (*Encarsia* sp.) from *Trialeurodes vaporariorum* has proved to be of considerable interest, as it appears to be a species not yet recorded from Britain." On 15th September a second letter was received from Dr. Waterston, who had sent the material to the United States, in which he says:—"I have now had a reply from Gahan regarding your parasite of *Trialeurodes vaporariorum*. He has compared it with *E(ncarsia) versicolor*, Gir., and finds it is not that species, but *E. formosa*, Gahan, which was subsequently reared from the same host."

Mr. Hawkins, who was the first to find *Encarsia formosa* in Britain, very kindly supplied full information concerning its appearance. He first noticed the black parasitised scales of white-fly upon some plants of *Cassia tomentosa* in a small greenhouse in March 1926. The seeds of these plants had been obtained from India in their pods and were sown in August 1925, germinating early in 1926. From the *Cassia* plants the parasite spread to white-fly on cucumbers in the greenhouse and soon eradicated its host upon these plants. It next appeared at the end of April upon tomato plants in the adjoining partition of the greenhouse, and the rate of increase during May, June and July was such that Mr. Hawkins was compelled to obtain plants heavily infested with white-fly from other sources in order to keep the parasite supplied.

A search at the end of July upon plants growing in the vicinity of the glasshouse revealed no trace of the parasite, but the infestation of white-fly was then very limited. This parasite and other species previously recorded may from time to time be imported into Europe and the United States on tropical plants, but in the case of *E. formosa* there is no direct evidence to show that they came from India. The adult may have been secreted amongst the *Cassia* pods mentioned, but it is not known if they could, in this state, have survived the journey from India. Further, we do not know if the species occurs in India at all. Certain characteristics of the habits point to the insect being of tropical origin.

### Life-history and Habits of *Encarsia formosa*.

*The Adult*.—The female parasite (Pl. xxiii, fig. 1), measuring only 0.6 mm. in length and 0.3 mm. in breadth, is a handsome object; the head is dark brown and the thorax black with yellow sides. The abdomen is uniformly bright yellow and shining, provided with a conspicuous ovipositor, which extends beyond the extremity of the body. Towards the posterior end of the body are a pair of large tubercles placed well

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\*Since identified as *E. partenopea*, Masi.

to each side, each bearing three long hairs. The antennae, 8-jointed and 0.5 mm. long, are light brown, and the legs brownish yellow. The wings are opalescent, covered regularly with short hairs and fringed with long hairs; their expanse is 1.5 mm.

The male (Pl. xxiii, fig. 2), which occurs somewhat rarely, is conspicuously larger than the female and is at once distinguished from it by the abdomen, which is dark brown; the antennae are longer than, and the genital appendages quite differently shaped from, the corresponding organs of the female sex. Both sexes are active at high temperatures (80–100° F.) and bask in sunshine. When touched or otherwise disturbed, they hop with great vigour, but can readily be caught by means of a small glass tube held over the surface on which they are resting. The females have been observed feeding upon the honey-dew secreted by the scale stages of white-fly.

*Parthenogenesis and the Occurrence of the Male.*—Though a number of males have been reared towards the end of September and a few again appeared at the end of October, mating has never been seen to take place. On both occasions low temperatures preceded the occurrence of these males, and in a glasshouse which was specially heated over these periods no males could be found. Amongst hundreds of parasites seen to emerge in July and August only females occurred, and these readily deposited eggs (which subsequently developed to maturity) immediately after emergence from the white-fly scale upon which each had subsisted. Seven males appeared in a total of over 100 specimens that emerged from 12th to 25th September. The fact that this insect is habitually parthenogenetic is an enormous advantage in rearing the parasite for economic purposes.

*Oviposition.*—After hovering round foliage of plants bearing white-fly scales, the female settles usually on the underside of a leaf, and walks over it, touching the scales with her antennae. Having selected a scale in a suitable stage of development, she climbs upon it and thrusts her ovipositor into the dorsal surface of the scale, holding her body in a nearly vertical position. The exact spot at which the ovipositor pierces the scale appears to be slightly anterior to and to the left or right of the operculum. In this attitude the female rests for some four minutes, and after retracting the ovipositor, walks away and performs vigorous cleaning motions. It is difficult to induce the female to oviposit in scales upon detached leaves, but in one case thus observed an exudation of a yellowish transparent material was found above the place where the ovipositor had been inserted. No trace of the point of insertion could be found, and the secretion dissolved quickly on fixation of the scale.

Examination of a large number of white-fly scales in various stages of development showed that the parasite oviposits in the white-fly pupa, and at a period shortly after the third ecdysis (Pl. xxiv, figs. 1–3). At this stage, the fourth in the white-fly life-cycle, the scale is still flat, and the building up of the wax covering in a vertical plane has not begun. This latter process is not interfered with by actual oviposition of the parasite, but is prevented if the parasite egg hatches before it has begun. In warm weather during July and August the parasite egg is deposited in the scale about 11 days after the latter hatches from its own egg, *i.e.*, some three weeks after the white-fly egg hatches.

It is probable that this is the only period selected by the parasite for oviposition, though once an *Encarsia* was seen to sit over a late pupa, which subsequently died, but no parasite emerged.

In no case has more than one parasite egg been found in a scale. It has not been possible to obtain exact data of the number of scales parasitised by a single female, but it is evident that under favourable conditions a considerable number of eggs are laid. Between 12th and 21st July, 3 females kept in a glass cylinder and moved from branch to branch of a plant laid eggs in 98 scales, but oviposition was certainly not complete at the end of this period. From 83 female parasites emerging from these

scales in the middle of August, supplemented by 8 from another source, 660 parasitised scales were counted on 4 potato plants, and quite double that number were present on tomato plants in the same glasshouse at the beginning of September.

In a tomato-house in which 20 parasites were liberated on 14th August, at least 1,000 parasitised scales made their appearance between 1st and 8th September. It is therefore probable that each female parasite is capable of laying some 50 eggs and thus destroying 50 white-fly scales, but at low temperatures oviposition is much restricted, and the slow development of white-fly scales under such conditions must present few pupae in the right stage of development to receive the parasite egg at any one time.

Female parasites have been observed late in the season to rest for days on leaves where only very young scales were present, as if waiting until the latter should reach the right stage of development to receive an egg.

The egg of *Encarsia formosa* (Pl. xxiv, fig. 2) is a simple structure of comparatively large size. It measures 0.08 mm. in length and 0.03 mm. in greatest breadth, being rounded at the anterior and pointed at the posterior end. Anteriorly the egg membrane shows signs of convolution, but there is no "neck" so characteristic of most CHALCIDIDAE.

The position in which the egg is found in the scale varies considerably. Usually it is laid in the region of the "crop" (Pl. xxiv, figs. 1, 2), sometimes in the interior of the left or right anterior gonad, or to the outside of one of these (Pl. xxiv, fig. 3).

The duration of the egg stage has not been exactly determined; it appears to be not more than 4 days, as hatching often takes place before the white-fly pupa has begun to swell vertically.

*The Larva.*—The white limbless larva is, on hatching, dilated at the anterior end and soon becomes much elongated, showing signs of segmentation (Pl. xxiv, fig. 4). Growth is rapid and the larva becomes semicircular, much dilated anteriorly, and more distinctly segmented (Pl. xxv, fig. 1). The tissues of the scale appear to be absorbed through a small sucking-apparatus placed somewhat ventrally in the head region. No mouth-parts or eyes are visible. The eye-pigment of the white-fly scale disappears, and the skin beneath the wax plates (Pl. xxiii, figs. 3, 4) turns rapidly through grey to a shining black. These colour changes seldom occupy more than a period of 24 hours. Occasionally this blackening is reduced to mere streaks and rarely does not develop at all. The ventral skin of the scale usually retains the normal white or light grey colour. The larva occupies about half the cavity of the scale when blackening begins, and is surrounded by the collapsing tissues of the white-fly pupa.

The scales usually give evidence of being parasitised about 12 days after oviposition by the *Encarsia*, but there appears to be considerable variation, and the period may be extended to 21 days. It is well known that the scale stages of white-fly do not live long on foliage that has been removed from the plant, but during September parasites were reared from such material up to 23 days after removal of the foliage. Foliage bearing parasitised scales can therefore safely be removed from the plant as soon as the black colour appears without injury to the parasite. The number of moults of the larva appears to be three, from cast skins found inside scales containing pupae of the parasite (Pl. xxv, figs. 2, 3), and the larval stages occupy some 14 days.

*The Pupa.*—Soon after the pupal-skin of the white-fly has turned black, the whole white-fly pupa has been demolished by the parasite larva. The larval parasite, when full-fed, occupies at least two-thirds the cavity of the scale when it changes to the pupa. At first this is a white object without limbs, but gradually the buds of the antennae and legs grow from the ventral surface in a posterior direction, and when they have attained their full length, a process that occupies some 4 days, the colour of the adult is to some extent assumed within the pupal skin. The pupa of the parasite is readily distinguished from that of the unparasitised white-fly pupa by the short



wingfolds, the large antennae, and the character of the eyes. The head of the pupa lies usually towards the anterior end of the white-fly skin, thus occupying the same position as the normal white-fly pupa. Sometimes, however, it points in the opposite direction (Pl. xxv, fig. 3). The duration of the pupal stage is about 10 days.

*Emergence.*—The adult, on emergence from the pupal skin (Pl. xxv, fig. 3), is surrounded by the hard case of the white-fly scale with its external wax plates. In the roof of this it proceeds to cut a circular hole, through which it finally escapes. The position of this hole is determined by the direction in which the pupa of the parasite lay; in the majority of cases it is anterior, but if the larva has pupated with head towards the posterior end of the scale, the exit-hole is cut through the operculum. A parasitised white-fly pupa was detached from the leaf surface and kept ventral side upwards; the adult parasite here made its exit through the ventral surface, *i.e.*, the surface facing upwards, and in the posterior region of the scale, having rotated on its own axis. After cutting the hole, the *Encarsia* rests several hours before making its escape.

*Duration of Life-cycle.*—The normal life-cycle, from the laying of the egg to the emergence of the adult from the parasitised white-fly scale, is not less than 28 days. Emergence of adults of any one generation is continued over a period of at least 3 weeks, and it seems probable that the adult parasite may remain within the scale for some time before emerging. The length of life of the female must be considerable, as individuals have been kept ovipositing over a period of 9 days, and had then not deposited all their eggs. The stages of the life-cycle are mostly hidden from view, and the blackening of the scale considerably precedes pupation of the larva.

### Relation of Parasite to Host.

Dr. Ll. Lloyd<sup>7</sup> gives a record of the duration of the various stages in the life-cycle of the white-fly. For July the figures are, for the egg-stage 8–10 days, for the scale stages 10 days, for the pupa 8 days, making a total of 28 to 30 days.

The parasite thus oviposits in the scale when the latter is about 28 days old (counting from the laying of the white-fly egg), and the offspring of the parasite will begin to emerge about 20 days after the white-fly should have emerged from its pupa. The length of time over which a single female oviposits, coupled with the long period over which the emergence of the offspring may extend, is evidently an adaptation to ensure the parasite finding at least a fair proportion of scales at the right stage of development to receive an egg.

### Effect of Temperature on Fecundity.

There can be no doubt that *E. formosa* thrives best at high temperatures, and possibly in a moist atmosphere. Some 100 females emerging during July produced well over 1,000 offspring by the end of August in a small glasshouse at a high temperature, with a dry atmosphere. Twenty females were liberated in a block of tomato houses in August; temperatures were moderately high, and in September over 1,000 scales had been parasitised. To them were added another 2,000 parasitised scales. In September the temperatures fell very considerably, and the number of parasitised scales found at the beginning of October was most disappointing. The numbers increased again during this month, when fire-heat was put on. In two small houses, one kept hot and moist, and the other dry and cold, numerous parasites were present in September. During October there was an enormous increase in the hot house and only a very small number of parasitised scales was present in the cold house.

### Hibernation.

At present it is not certain how *E. formosa* passes the winter, if indeed it is able to do so in this country, without artificial heat. Leaves of tomato plants with numerous



parasitised scales were placed in a box on 30th September and kept outside. By 16th October the unparasitised pupae of white-fly on the leaves had all emerged, but no parasites had emerged up to 5th November. The *Encarsia* may therefore hibernate within the white-fly scale as a pupa or adult, and probably the adult is unable to spend the winter as such after escape from the scale. But the fact that the parasite continues to breed with artificial heat certainly suggests that *E. formosa* may be a tropical insect without a hibernating period.

### Distribution Capacity.

A leaf bearing some 20 parasitised scales was pinned to a tomato plant in a block of four glasshouses each measuring 100 ft. long by 27 ft. wide on 14th August 1926.

On 1st September, white-fly scales on the foliage of plants in the immediate vicinity in which the parasite had emerged began to turn black; on 8th September parasitised scales were also found 45 feet away in a south-westerly direction, and in another portion of the house 70 ft. in a northerly direction. No parasitised scales could be found between these points. The female parasite is therefore able to cover very considerable distances in the quest of white-fly scales in a stage suitable for oviposition.

### Experiments in Distributing Parasitised Scales of White-Fly.

With a view to the distribution of *Encarsia formosa* for the economic control of white-fly, three methods of collecting the parasitised scales were compared. In the first, 79 scales were removed from leaves and placed in small open glass tubes, which were tied to the stems of tomato plants; after 3 weeks the percentage of emergence was 91, six parasites having been injured in removal from the leaf upon which they developed. In the second, 104 parasitised scales were similarly treated, but placed in an open box on a raised stand; of these 19 did not emerge, the percentage of successful emergence being only 81. In the third, leaves with 58 parasitised scales were removed from plants and kept in an open box; 91 per cent. of them emerged.

A percentage of nearly 100 was obtained when whole branches were removed and pinned to fresh plants. It is evident that attempts to remove scales containing the parasite involves a loss of from 10 per cent. to 20 per cent. of the parasites through injury. On the other hand, there is danger in distributing leaves and branches of plants to nurseries owing to the risk of spreading red-spider and mildew, and there is much to be said in favour of removing parasitised scales from the foliage before distribution, unless leaves of such a plant as tobacco are used for cultivating the insect. The adult parasite will not live long away from the foliage of plants, 5 days being the maximum recorded.

### The Effect of Cyaniding

The generation of hydrocyanic acid gas from sodium cyanide and sulphuric acid is now an established practice in tomato nurseries for the control of white-fly. The quantity of sodium cyanide used on the average to every 1,000 cubic feet space is  $\frac{1}{4}$  ounce.

On 10th October 1926, a block of 4 tomato houses, in which *Encarsia formosa* had been reared and in which a number of white-fly scales were parasitised, was fumigated, using a full  $\frac{1}{4}$  ounce sodium cyanide to 1,000 cubic feet. Parasitised scales were collected on 11th October, and between 13th October and 5th November 69 females and 2 males emerged. Another fumigation was carried out on 20th October, using rather more cyanide; between 26th October and 5th November, 61 female *Encarsia* emerged from parasitised scales collected from the houses 2 days after the fumigation. In both these cases, emergence was probably still in process after 5th November.

Owing to the length of time over which the adults escaped from the scales, it appears that larvae of the parasite may complete their development in white-fly scales which have been killed by fumigation.

Adult *Encarsia* are fairly soon stupefied by a very strong concentration of hydrocyanic acid gas, but they are probably not killed in the ordinary process of fumigation in glasshouses. A similar instance of a Chalcid parasite being unaffected by cyanide is mentioned by E. E. Green,<sup>4</sup> who subjected parasitised individuals of a species of *Lecanium* to strong hydrocyanic acid gas for 15 hours, after which the parasites emerged in large numbers.

### Acknowledgements.

These notes have been written primarily from an economic standpoint.

Dr. Kenneth Smith, of Manchester University, obtained material of *Encarsia formosa*, and very generously offered to give up working upon the parasite when he became aware that investigations were in progress at the Cheshunt Experimental Station.

Dr. Smith was strongly urged to continue his work, and it is hoped that his investigations may lead to elaboration of such details of the life-history as have been touched upon here, and to a detection of scientific inaccuracies which are prone to find their way into economic study.

To Dr. J. Waterston and Mr. G. Fox-Wilson thanks are tendered for much help and advice, and to Dr. F. Bewley for special facilities granted in connection with experiments in breeding the parasite.

### Summary.

1.—*Encarsia formosa*, Gahan, is a Chalcid wasp that parasitises the white-fly, *Trialeurodes vaporariorum*, Westw., a single female ovipositing in 50 or more young pupae of the host. The larvae of the parasite, on hatching from the egg, destroys the white-fly pupa, the skin of which becomes black in colour, thus distinguishing the parasitised pupa from the normal white scales and pupa of the white-fly.

2.—The parasite is parthenogenetic, males, probably impotent, only appearing when temperatures are low.

3.—The life-history of the parasite occupies at least 28 days, and adults may remain in the scales for some time before cutting their way out by a circular hole in the roof of the scale. The adult is capable of travelling over large areas in glasshouses.

4.—Low temperatures militate seriously against the increase of the parasite, which is probably a tropical insect and has possibly been imported into this country from India.

5.—Fumigation with hydrocyanic acid gas, as practised commercially for the control of white-fly, does not affect the parasites.

6.—The parasite is best distributed by detaching the black pupae of white-fly from the foliage, though 20 per cent. may be injured in this way. An almost complete emergence is obtained by cutting branches from plants and pinning them to the plants in houses where distribution is desired, but this involves risk of infecting the houses with various pests and diseases.

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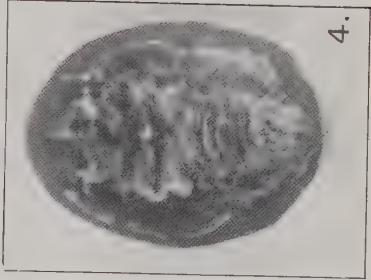
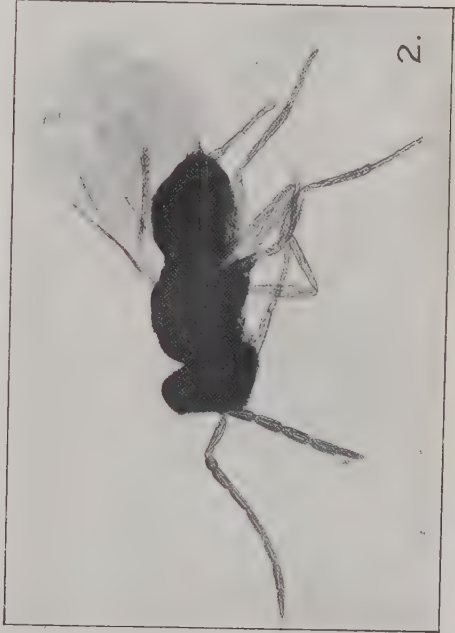
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EXPLANATION OF PLATE XXIII.

- Fig. 1. *Encarsia formosa*, Gahan, adult female ( $\times 64$ ), from above.  
,, 2. *Encarsia formosa*, adult male ( $\times 64$ ), side view.  
,, 3. Tomato leaf showing black pupae of *Trialeurodes vaporariorum*, Westw., parasitised by *Encarsia formosa*, and white unparasitised pupae of the former ( $\times 2$ ).  
,, 4. Pupa of *Trialeurodes vaporariorum* parasitised by *Encarsia formosa* ( $\times 64$ ), dorsal view.



*Encarsia formosa*, Gahan, a parasite of *Trialeurodes vaporariorum*, Westw.

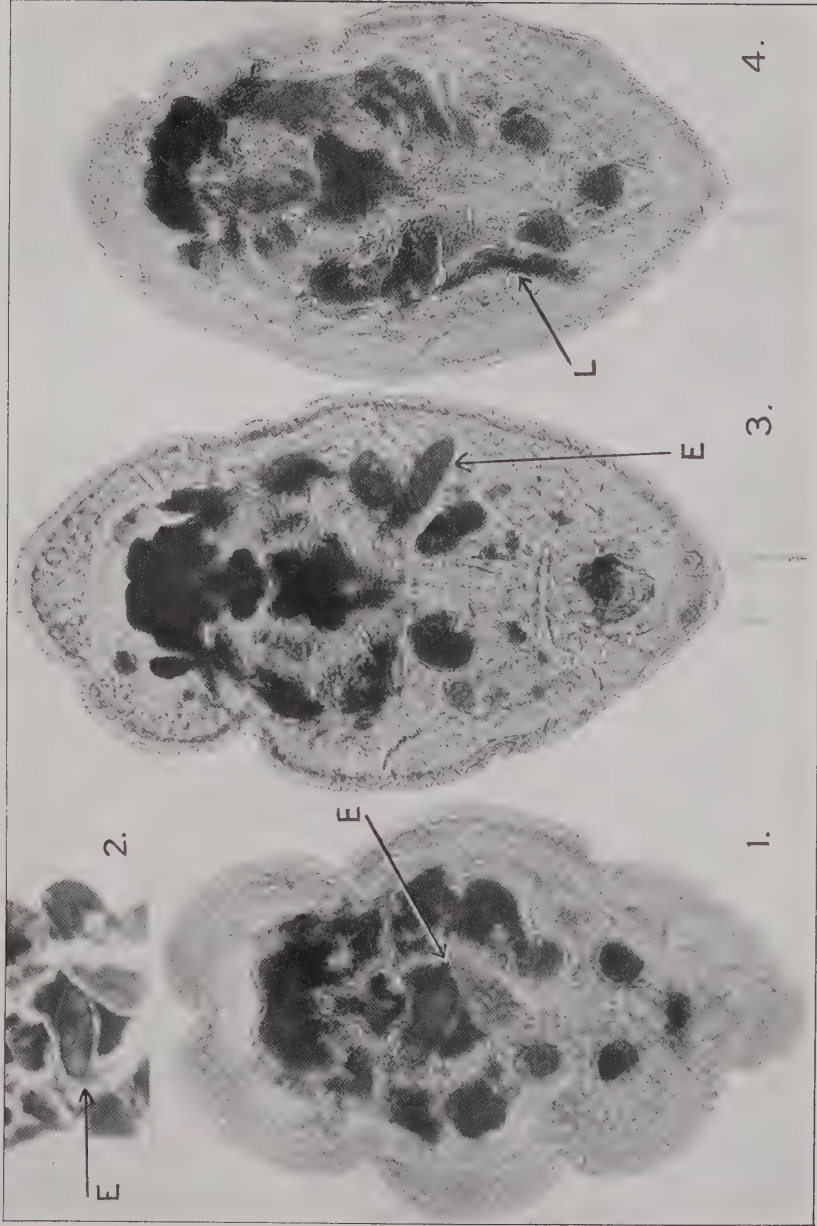






EXPLANATION OF PLATE XXIV.

- Fig. 1. *Trialeurodes vaporariorum*, Westw., pupa containing egg (E) of *Encarsia formosa* in the region of the crop ( $\times 150$ ), from ventral side.
- „ 2. Egg (E) of *Encarsia formosa* ( $\times 150$ ).
- „ 3. *Trialeurodes vaporariorum*, pupa containing egg (E) of *Encarsia formosa* in the region of the gonad ( $\times 150$ ), from dorsal side.
- „ 4. *Trialeurodes vaporariorum*, pupa containing young larva (L) of *Encarsia formosa* ( $\times 150$ ), from dorsal side.



Early stages of *Encarsia formosa*, Gahan, in *Trialeurodes*.

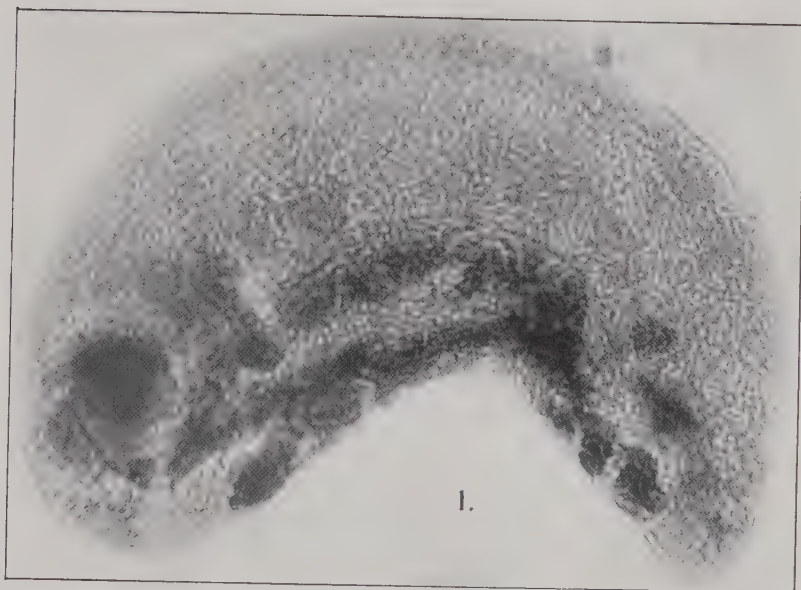






EXPLANATION OF PLATE XXV.

- Fig. 1. *Encarsia formosa*, Gahan, full-fed larva ( $\times 150$ ) extracted from pupal skin of *Trialeurodes vaporariorum*, side view.
- „ 2. *Encarsia formosa*, advanced pupa ( $\times 60$ ) within pupal skin of *Trialeurodes vaporariorum*: LS, moulted larval skins of *E. formosa*; O, operculum of *T. vaporariorum*.
- „ 3. *Encarsia formosa*, adult ready to emerge from pupal skin of *Trialeurodes vaporariorum* ( $\times 60$ ): LS, moulted larval skins of *E. formosa*; PS, moulted pupal skin of *E. formosa*; O, operculum of *T. vaporariorum*.



Early stages of *Encarsia formosa*, Gahan.



ON TWO NEW PARASITES FROM WEST AFRICA BRED FROM THE CACAO  
BARKSAPPER (*SAHLBERGELLA*).

By D. S. WILKINSON,

*Senior Assistant, Imperial Bureau of Entomology.*

Family BRACONIDAE.

Subfamily EUPHORINAE.

***Euphorus sahlbergellae*, sp. n.**

Head, thorax, and abdomen deep black, polished and shining; scape, flagellum (except about 17 apical joints which are darker), palpi, tegulae, all trochanters, front femora, about apical third of mid femora, hind femora at extreme apex, the 4 anterior tibiae and tarsi, basal third of hind tibiae, light red-brown; basal two-thirds of mid femora, apical two-thirds of hind tibiae on underside, and hind tarsi, dark red-brown; hind femora and apical two-thirds of upper surface of hind tibiae black to dark red-black; hind coxae, and mid coxae mostly, black; front coxae, at least at the sides, black, apically somewhat red-brown; claws dark; stigma and most wing-veins brown.

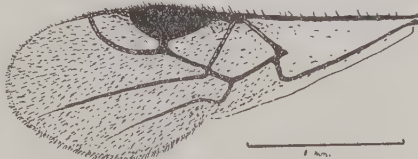


Fig. 1. *Euphorus sahlbergellae*, sp. n., wing.

*Head* transverse, broader than thorax; clypeus transverse, more than twice as broad as long; face completely, and frons along the inner orbits, lightly punctate; remainder of head capsule smooth, with only occasional isolated punctures; face, cheeks, apical margin of clypeus, and basal half of mandibles clothed with longish white pubescence; antennae longer than head and thorax together, with 24–25 flagellar joints, and densely clothed with short pubescence; lateral pits of the clypeus (depressions leading to the tentorial apodemes) large and deep. *Thorax*: propleurae carinate; mesonotum smooth and unsculptured, with broad, straight, deep notauli, which may or may not be slightly crenulate, and which converge posteriorly at an angle of 60° but do not quite meet; anteriorly each notaulus is continued as a well-marked but shallower and narrower sulcus backwards round the anterior lateral margins of the pronotum, and finishes in a deeper depression somewhat behind the tegulae; the smooth unsculptured scutellum is separated from the mesonotum, except for a thin median keel and for a somewhat lower keel on each side, by the scutellar depression, which is broader than the base of the scutellum and about two-thirds as long as the scutellum; the scutellar depression is about as far from the converging points of the notauli as these latter are from one another; posteriorly the flat mesonotum terminates abruptly and becomes more or less steeply declivous towards the metathorax, and exhibits on each side a large, slightly excavate, carinate area, which areas extend on to the sides of the scutellum but do not meet across the side of the rounded, smooth, more or less steeply declivous apex of the scutellum; mesopleurae smooth and margined with crenulate sulci, with a short, perpendicular, deeply crenulate sulcus at the base of the anterior third, below, from the apex of which a shallow, lightly crenulate sulcus runs backwards obliquely; metathorax deeply crenulate; propodeon reticulate-rugose; pro- and mesothoracic sternites and propodeon with sparse white pubescence. *Wings* (fig. 1) hyaline and, except in the costal and median cells of



the forewing, densely haired ; radial cell short, the metacarp about two-thirds the length of the stigma ; radial springing from beyond the middle of the stigma, its 1st abscissa very short, almost punctiform, and its 2nd (exterior) abscissa evenly curved ; recurrent vein interstitial ; nervulus very slightly postfurcal ; median wanting ; stigma large. *Legs* with sparse white pubescence ; coxae short ; the apical joint of all tarsi elongate and much broadened apically ; empodia considerably distended. *Abdomen* : petiole somewhat greater than half dorsal length of remainder of abdomen, enlarged posteriorly, straight-sided, arched, and striolate on its upper surface except at immediate apex, which is somewhat more than  $1\frac{1}{2}$  times as broad as the base ; petiolar spiracular tubercles fairly prominent ; 2nd segment apparently transverse and shorter than petiole ; 3rd segment longer than 2nd and hardly transverse ; 4th, 5th, and 6th very short ; exact position of the 2nd suture more or less indeterminable, at least in two examples ; in one example no abdominal suturing discernible after the 1st ; tergites smooth, polished and bare, except that the anus is surrounded by a tuft of setae ; the tergites extend over and hide the ventrites, only the 9th ventrites being visible, and these latter, clothed with sparse white pubescence, are prominently extruded with the ovipositor, which in three examples definitely exceeds, and in the remaining example is definitely exceeded in length by, the longer hind calcaria.

*Length*, 4 mm.

*GOLD COAST* : Asamankese, East Province, 4 ♀♀, 1926 (G. S. Cotterell).

*Type* in British Museum.

*Host* : bred from the Capsid bug, *Sahlbergella singularis*, Hagl., which is a serious pest of cacao trees in the Gold Coast.

## Family ICHNEUMONIDAE.

### Subfamily OPHIONINAE.

#### **Mesochorus melanothorax**, sp. n.

Thorax, ovipositor sheaths, and dorsum of abdomen (except extreme apex of 2nd segment and extreme base of 3rd in middle somewhat) black and shining ; vertex and occiput dark shining reddish-black ; face, antennal scape, mandibles basally, lower portion of cheeks, front and middle legs, tegulae, the lateral membranous margins between apex of petiole and base of 3rd segment, base of 3rd segment in middle somewhat, whole of extreme apex of 2nd, and basal three-fourths of hind tibiae, pale testaceous ; hind coxae, hind femora, hind tarsi, and male processes somewhat darker ; apical fourth of hind tibiae blackish ; stigma and wing veins concolorous dull light brownish, and antennae of a somewhat darker brown.

*Head* short, broader than thorax ; clypeus not or hardly separated from face ; face punctate ; in the female, clypeus sparsely punctate ; in the male, punctate only on sides and apex, smooth in the middle and basally ; face with a strong, transverse carina, which is V-shaped in the middle, running below, and connecting the apices of, the toruli, and with a slightly raised median area running from below the transverse carina to base of clypeus, which area in the female is somewhat aciculate and in the male striate ; cheeks sparsely punctate ; lower facial orbits not striate ; antennae filiform, longer than head, thorax, and abdomen together, in the male nearly three times, and in the female about twice, as long as abdomen ; 1st flagellar joint longer than scape, about as long as 2nd and 3rd joints together ; flagellar joints in female 34, in male 32 ; face and antennae thickly, cheeks sparsely, pubescent. *Thorax* : pronotum with median transverse crenulate sulcus ; mesonotum and prosternum evenly and lightly, but somewhat sparsely, punctate ; mesopleurae coarsely punctate on lower half, lightly punctate below insertion of forewings, and more or less smooth in the middle ; basal depression of scutellum with fairly strong lateral carinae which continue round the lateral margins of the mesonotum ; scutellum in the female sparsely

punctate, in the male more or less entirely smooth; apex of scutellum below with a minute tooth; propodeon (fig. 2) with strong carinae forming at least 10 superior areae;



Fig. 2. *Mesochorus melanothorax*, sp. n., propodeon.

basal area small and apparently confluent with areola; areola narrower at base than apex, the greatest width being beyond middle, nearly twice as long as broad; petiolar area broader at middle than apex, and broader at apex than base, somewhat longer than greatest width, which is at about middle; costulae longer than extreme width of areola; thorax sparsely pubescent. *Wings* clear hyaline; nervulus interstitial; nervus parallelus emitted from above the middle of brachial cell; areolet almost true rhombic, large; nervellus straight and unbroken. *Legs* thickly pubescent; hind coxa and trochanter together somewhat longer than petiole; the longer hind calcaria half as long as basal joint of hind tarsus, which latter is as long as the 2nd, 3rd, and 4th joints together of the hind tarsus. *Abdomen*: petiole very slightly arched, with spiracles beyond middle, and with its apex half as broad again as base, the apex being about one-third total length of petiole; a slight, shallow, broad depression is exhibited on the upper surface of the postpetiole, otherwise the petiole is more or less smooth and polished; 2nd segment transverse, shorter than apically broad but longer than basally broad; 3rd transverse, slightly longer than 2nd; succeeding segments transverse and shorter than 2nd; 4th and succeeding segments very distended laterally and folded down so as completely to hide their ventrites; 2nd and succeeding segments smooth and polished; ovipositor, and mid femur of about equal length, both somewhat shorter than petiole; male processes in length about equal to the 2nd segment.

*Length*, 3.5-4.0 mm.

GOLD COAST, Asamankese, East Province. 2 ♂♂, 2 ♀♀, 1926 (G. S. Cotterell).

*Type* in the British Museum.

*Host*: bred from *Sahlbergella singularis* at the same time as *Euphorus sahlbergellae*, sp. n., and there can therefore be no doubt but that it is parasitic on this latter species.



SOME NOTES ON *SYRINGOPAIS TEMPERATELLA*, LED., IN CYPRUS.

By D. S. WILKINSON,

*Senior Assistant, Imperial Bureau of Entomology; W.*  
*lately Government Entomologist, Cyprus.*

It has just lately been reported to the writer that *Syringopais* (*Nochelodes*) *temperatella*, Led., a Microlepidopteron of the family OECOPHORIDAE, has again in Cyprus begun to assume the rôle of a major pest. Little work seems to have been done on this insect anywhere, so that it may be worth while to give a few notes on one or two interesting points that have lately been brought to light with regard to it.

On first appointment to the island, in 1923, the writer was given to understand that *Nochelodes temperatella* was the greatest insect pest with which the impoverished and struggling farmer had to deal; but that this is indeed the whole truth was not entirely borne out by enquiries during the years 1924, 1925, and early 1926, for it was found that no serious endeavour to deal with the insect on the lines previously advocated by the Agricultural Department had ever been made, despite the fact that cultural methods only had been advocated, and in addition such as could easily have been carried out with the exercise of no great energy.

Broadly, the life-history of the insect is as follows:—The adults are on the wing in the late spring or early summer, some little time before the wheat is cut. It is supposed that the eggs are laid in the soil—certainly they are to be found in the soil—and that they there persist through the hot weather, hatching some time during the winter, and the larvae immediately proceeding to attack the young wheat. The pest becomes really noticeable only towards the spring, when sometimes whole areas of wheat are virtually destroyed. Pupation takes place in the soil.

The cultural methods advocated would, if systematically and conscientiously carried out, undoubtedly go far to alleviate the position. But these methods entail work, and work of a somewhat unusual nature, and to this the Cypriot farmer is not very partial. In view of the presence of the eggs in the soil during the summer months it was advocated that after the harvest all infested land should be thoroughly ploughed and rolled. This in theory is sound, but unfortunately the farmer is probably correct in raising objections to this method in that by the end of the harvest, or at least by the time that the threshing is complete (a primitive and lengthy task in Cyprus, necessitating the use of all available men and animals) the soil is already baked quite hard, or at least sufficiently hard as to occasion some labour to the farmer, using as he does the antiquated wooden plough of his forefathers. It was also advocated that the stubble should be immediately burnt. The exact value of this measure is not apparent to the present writer, and it was even more unpopular than the provision in the Order to enforce summer ploughing, since during the summer Cyprus is almost entirely devoid of green feed, and wheat stubble and the sprouting weeds previously protected by the standing wheat are very largely used as grazing. It was further recommended that, where possible, wheat in infested areas should not be grown on the same land for two years in succession. To the writer's knowledge this was attempted in at least one village area, and proved to be very satisfactory, but it is not a measure that could be generally adopted, except under a strict communal system of farming, since the areas of land farmed by individuals are too small. It is, however, a measure of protection that could very advantageously be employed by the Government should the present outbreak seriously develop over a number of years throughout the island.

This insect has in Cyprus a somewhat anomalous distribution, there being certain more or less definitely limited areas in which it persists in a marked degree year after year, while in neighbouring areas, removed in some cases by only a mile or two, it exists, if at all, in such small numbers as almost to defy detection. Three such areas of abundance are known to the writer, two of them being surrounded by forests or stony, more or less barren land. Investigation has so far failed to reveal the reason for



these inequalities, but the matter is well worth further enquiry, because this may lead to the discovery of the factors which normally control the multiplication of the species.

The adult moths, which incidentally exhibit remarkable sexual dimorphism, are active, strong fliers, and in some localities in Cyprus may be observed in countless numbers engaged during the heat of the day both in feeding on the flowers of weeds growing along the banks beside the standing wheat, or among the wheat itself, and in sexual play. In the early morning or late evening they are sluggish, but can be beaten from the grass or wheat, and it was therefore with some doubt that the writer attempted to attract them by light. In the early part of one night an ordinary oil hurricane lantern was lighted and exhibited in a cornfield at the height of about two feet above the standing wheat, and within rather more than ten minutes the oily glass of the lamp was almost completely covered by adherent dying moths. Whether or not, however, the utilisation of powerful modern light-traps would be an economic proposition or would materially assist in the control of this pest remains to be ascertained.

Finally, it is interesting to note that wheat fields that have been attacked severely produce no grain whatever, or hardly any, unless, after the pupation of the pest, there is rain sufficient to bring about the recuperation of the attacked crops. This late rain does not always occur, and in view of the abnormally heavy rainfall in Cyprus during the latter months of 1925 and in early 1926 it is possible that these late spring rains have failed this year, thus probably once again emphasising, over a large area, the presence of the pest.

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## R. TABANIDAE OF THE SAMOAN ISLANDS.

By EUSTACE W. FERGUSON. W.

So far no species of this family of Diptera have been described or recorded from the Samoan Islands. The acquisition of a species of *Tabanus* by Dr. P. A. Buxton and Mr. G. H. E. Hopkins is therefore of great interest.

The TABANIDAE of the Pacific Islands undoubtedly form an eastward extension of the family from Papua through Melanesia to Fiji; various species are known from the Solomons, New Hebrides, New Caledonia, the Loyalties and Fiji, but the family is unrecorded from Tonga or islands to the eastward of Samoa. The TABANIDAE thus represent a Papuo-Melanesian element in the Polynesian fauna. It might be mentioned here that two species of *Tabanus*, *T. sidneyensis* and *T. nigriventris*, were described by Macquart from "Sidney Island," which has been supposed to be Sidney Island in the Phoenix group. This locality is certainly erroneous; most of the Diptera described as coming from there are known now to be common Australian forms and these two species are in all probability also Australian. The only other species recorded from Polynesia proper is *T. insularis*, Walker, described from the Sandwich Islands; this record is also certainly wrong, since the group is not known to occur in these islands, of which the fauna has been extensively collected.

The Melanesian species, so far as known, are related to species occurring in Papua and in the north of Australia; the Fijian species appear also to be of this type, and the Samoan representative clearly belongs to the same group. Material from Fiji and the New Hebrides is not available for comparison, but the Samoan species differs from the descriptions of all described from these islands in details of structure and colour. I have compared it with a Papuan species, *T. torresi*, which occurs also within Australian territorial limits, and which is structurally rather closely allied. Many of the TABANIDAE are wide ranging species, *T. ceylonicus*, Schiner, for example, ranges from Ceylon to the Solomon Islands and to North Queensland; it is not surprising, therefore, that the family should have been able to reach Samoa, where the presence of mountains with permanent waters would give the conditions necessary for breeding. The isolation would account for the evolution of specific differences.

### ***Tabanus samoensis*, sp. n.**

A medium-sized dark brown species, related to *T. torresi*, Ferg. & Hill.

♀. Front narrow (fig. 1), slightly narrower anteriorly than at vertex, about seven times as long as width anteriorly; clothed with greyish yellow tomentum, and sparse black hairs; callus dark brown, shining, elongate, not reaching sides, with a long extension practically to vertex; subcallus densely clothed with fawn-coloured tomentum; face with more greyish tomentum changing to fawn above, some dark pubescence on inner orbits, pubescence elsewhere white; palpi brownish yellow, rather thickly clothed with short, black pubescence, 2nd joint stout and pointed, somewhat, but not greatly, produced; antennae brown, the apical four annuli of 3rd joint black; 1st joint subcylindrical, 2nd short, both with dark hairs, 3rd elongate, rather slender, with well-marked tooth on basal part; eyes subnude. Thorax dark brown, clothed with dark tomentum, with indistinct grey tomentose stripes: a narrow median stripe in anterior half, a dorsocentral and a sublateral stripe on each side; pubescence short, dark, some longer white pubescence above and behind wing roots; pleural segments densely grey tomentose, with white pubescence; scutellum dark brown, similar to mesonotum. Abdomen uniform dark brown, rather bare and shining, the extreme lateral margins brownish yellow; pubescence scanty, appressed, dark, pale yellow on lateral margins. Venter similar. Legs black, with black pubescence, coxae with grey tomentum and white pubescence. Wings rather dark

brown, slightly lighter posteriorly; venation normal, R4+5 without appendix. Calypters dark brown with black margin; halteres brown with yellowish brown stem. Dimensions: 10–13 mm.

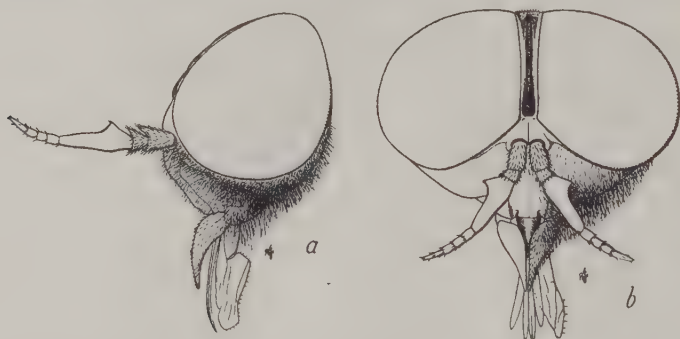


Fig. 1. Head of *Tabanus samoensis*, sp. n., ♀; a, lateral view; b, front view.

SAMOA: Malololelei, Upolu Island, 2,000 feet, 18.iv.1924, type and one paratype; three paratypes, same locality, 1.v.24, 4.v.24, 25.xi.24 (Buxton & Hopkins); Pago Pago, Tutuila, one paratype (E. H. Bryan).

The type is in the British Museum (Natural History); paratypes in the Bishop Museum, Honolulu, the author's collection, and the collection of the London School of Hygiene and Tropical Medicine.

The specimens show some variation in size but are certainly representative of but one species. The eyes are described as subnude, since in the type sparse short hairs are seen to be present, though on the other specimens these are hardly traceable. The greyish pubescence on the mesonotum is extremely indistinct and the lines difficult to trace; in addition to the rather scanty pale pubescence near the wing roots there are sometimes some paler hairs on the posterior border of the dorsum and on the sides of the scutellum.

The contrast between the general dark brown (almost chocolate) colour and the grey tomentose pleurae is rather striking.

The species is most closely related to *T. torresi*, Ferg. & Hill, which occurs in Moa Island of Torres Strait and also in Papua, but differs in the narrower front, shorter rather stouter palpi, and in details of coloration and clothing.

## COLLECTIONS RECEIVED.

The following collections were received by the Imperial Bureau of Entomology, between 1st July and 30th September, 1926, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Dr. G. ARNOLD, Rhodesia Museum :—2 Rhynchota, 50 Orthoptera, and 2 Trichoptera ; from Rhodesia.

Mr. E. BALLARD, Commonwealth Cotton Entomologist :—9 Diptera, 4 Lepidoptera, 1 species of Coccidae, 3 other Rhynchota, and 5 Psocidae ; from Queensland and New Guinea.

Capt. P. J. BARRAUD :—24 Culicidae, 2 larval and 2 pupal skins, and 4 microscope slides of genitalia ; from Punjab, India.

Mr. L. E. W. BEVAN :—7 Diptera ; from Southern Rhodesia.

Mr. G. E. BODKIN, Government Entomologist :—51 Lepidoptera ; from Palestine.

Dr. G. BONDAR :—24 Coleoptera and 2 Rhynchota ; from Brazil.

Mr. H. E. BOX :—19 Diptera, 166 Coleoptera, 6 Lepidoptera, 20 species of Coccidae, 2 species of Aphidae, 2 other Rhynchota, and 25 Psocidae ; from Venezuela.

Dr. P. A. BUXTON, London School of Hygiene and Tropical Medicine :—201 Culicidae, 2 other Diptera, 3 Coleoptera, 3 Hymenoptera, and 10 Lepidoptera ; from various localities.

Dr. A. E. CAMERON :—20 Tabanidae ; from Canada.

Mr. L. D. CLEARE, Junr., Government Economic Biologist :—54 Diptera, 4 Coleoptera, 8 Hymenoptera, 7 Rhynchota, and 7 Orthoptera ; from British Guiana.

COLOMBO MUSEUM :—56 Orthoptera ; from Ceylon.

Mr. G. S. COTTERELL :—5 Parasitic Hymenoptera ; from the Gold Coast.

DIVISION OF ENTOMOLOGY, PRETORIA :—5 *Haematopota*, 5 *Glossina*, 2 other Diptera, 172 Coleoptera, 26 Hymenoptera, 9 Lepidoptera, 64 Rhynchota, and 3 Orthoptera ; from South Africa.

Dr. L. H. DUNN :—3 *Culicoides* and 3 pupal skins ; from Southern Nigeria.

DURBAN MUSEUM, NATAL :—44 Rhynchota ; from South Africa.

Mr. A. M. EVANS :—7 Rhynchota and 10 nymphs ; from Sierra Leone.

Dr. E. W. FERGUSON :—19 Syrphidae ; from New South Wales.

Mr. C. FRENCH, Junr. :—3 species of Coccidae and 1 species of Aphidae ; from Victoria, Australia.

Mr. W. W. FROGGATT :—4 Diptera, 31 Coleoptera, 24 Hymenoptera, 1 species of Coccidae, and 8 other Rhynchota ; from New South Wales.

Lieut. J. GHESQUIÈRE :—424 Coleoptera and 14 early stages, and 2 Rhynchota ; from Belgian Congo.

Mr. P. v. d. GOOT :—23 Lepidoptera and 23 Rhynchota ; from Java.

GOVERNMENT ENTOMOLOGIST, LYALLPUR :—26 Diptera, 1 species of Aleurodidae, 2 tubes of Aleurodid pupae, and 57 other Rhynchota ; from Punjab, India.

Mr. C. C. GOWDEX, Government Entomologist :—80 Coleoptera, 24 Hymenoptera, 2 Lepidoptera, 8 species of Coccidae, 1 species of Aphidae, 8 other Rhynchota, and 2 Orthoptera ; from Jamaica, Salvador, and Colombia.

Mr. G. L. R. HANCOCK, Assistant Entomologist :—101 Hymenoptera and 45 Lepidoptera ; from Uganda.

Mr. E. HARGREAVES, Government Entomologist :—37 Culicidae, 19 *Forcipomyia*, 8 Tabanidae, 6 *Stomoxys*, 89 other Diptera and 8 pupa cases, 472 Coleoptera and 137 early stages, 100 Hymenoptera, 71 Lepidoptera, 12 species of Coccidae, 230 other Rhynchota, 98 Orthoptera, 8 Planipennia, 2 Hemerobiidae, and 9 Trichoptera ; from Sierra Leone.

Mr. H. HARGREAVES, Government Entomologist :—6 Culicidae, 37 Tabanidae, 3 *Glossina*, 176 other Diptera, 22 Coleoptera, 3 Lepidoptera, 3 Rhynchota, and 2 Planipennia ; from Uganda.

Mr. E. HODGKIN :—17 Parasitic Hymenoptera ; from Somerset.



Mr. F. G. HOLDAWAY :—2 Coleoptera, 10 Hymenoptera, and 70 Collembola ; from South Australia.

Mr. G. V. HUDSON :—19 Diptera and 79 Coleoptera ; from New Zealand.

IMPERIAL INSTITUTE, LONDON :—4 Lepidoptera ; from Africa.

Dr. A. INGRAM :—63 Siphonaptera ; from South Africa.

INSPECTOR-GENERAL OF AGRICULTURE, BAGHDAD :—6 Coleoptera ; from Iraq.

Mr. F. P. JEPSON :—1 Scolytid beetle ; from Ceylon.

Mr. C. B. R. KING :—69 Lepidoptera ; from Nyasaland.

Mr. T. W. KIRKPATRICK :—35 Hymenoptera and 10 species of Coccidae ; from Kenya Colony.

Mr. S. LEEFMANS :—5 Lepidoptera and 1 Acridid ; from Java.

Dr. LI. LLOYD :—234 *Glossina*, 3 other Diptera, 693 Coleoptera, 160 Hymenoptera, 164 Lepidoptera, 122 Rhynchota, 128 Orthoptera, 15 Planipennia, and 6 Odonata ; from Northern Nigeria.

Mr. F. R. MASON :—78 Coleoptera and 285 Orthoptera ; from various localities.

Mr. N. C. E. MILLER :—562 Orthoptera ; from Tanganyika Territory.

Mr. R. K. NARIMAN :—9 Rhynchota ; from Bombay, India.

NATIONAL MUSEUM, MELBOURNE :—9 Culicidae ; from Australia.

Mr. L. OGILVIE, Plant Pathologist :—2 Diptera, 3 Coleoptera, and 40 Lepidoptera ; from Bermuda.

Mr. C. PAPACHRYSOSTOMOU :—15 Diptera, 178 Coleoptera, 169 Hymenoptera, 50 Lepidoptera, and 61 Rhynchota ; from Cyprus.

Mr. W. H. PATTERSON, Government Entomologist :—386 Coleoptera and 3 larvae, and 10 Chalcididae ; from the Gold Coast.

Mr. H. M. PENDLEBURY :—1,266 Coleoptera ; from the Federated Malay States.

Mr. A. W. J. POMEROY :—2 Coleoptera and 3 early stages, 3,578 Isoptera, 8 Orthoptera, and 2 Embiididae ; from the Gold Coast.

Mr. Y. RAMACHANDRA RAO, Government Entomologist :—12 Lepidoptera and 20 Rhynchota ; from South India.

Mr. A. H. RITCHIE, Government Entomologist :—3 Culicidae, 2 *Haematopota*, 13 other Diptera, 563 Coleoptera, 1,000 Thysanoptera, 3 species of Coccidae, 21 other Rhynchota, 2 Orthoptera, 2 Embiididae, and 20 Collembola ; from Tanganyika Territory.

Mr. J. I. ROBERTS :—2 *Glossina*, 30 Coleoptera, and 1 Nematode Worm ; from Southern Rhodesia.

Mr. M. SIAZOV :—79 Orthoptera ; from Eastern Transcaucasia.

Mr. H. W. SIMMONDS, Government Entomologist :—5 Coleoptera and 5 Lepidoptera ; from Fiji Islands.

Mr. C. SMEE, Government Entomologist :—4 Coleoptera, 2 Lepidoptera, and 10 Rhynchota ; from Nyasaland.

Mr. A. TONNOIR :—2 species of Aphidae ; from New Zealand.

Mr. R. VEITCH, Chief Entomologist :—6 Rhynchota ; from Queensland, Australia.

Prof. J. WAGNER :—66 Orthoptera ; from Serbia.

WELLCOME TROPICAL RESEARCH LABORATORIES, KHARTOUM :—30 Chalcididae and 8 Orthoptera ; from the Sudan.

Mr. E. J. WELSFORD :—2 Lepidoptera ; from Zanzibar.

Mr. H. WHISTLER :—257 Orthoptera ; from Simla, India.

Mr. D. S. WILKINSON :—9 Tabanidae and 2 Bombyliidae ; from Italy.

Mr. R. C. WOOD :—63 Lepidoptera ; from Nyasaland.

## STUDIES IN AFRICAN TACHINIDAE (DIPTERA).

By C. H. CURRAN, (U)

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During the study of the Nearctic TACHINIDAE it became obvious that, in order to secure an adequate idea of the relationships of the various genera, it would be advisable to study representatives of the family from all parts of the world, and requests for African material met with hearty response from several sources. The extensive collection made by the American Museum of Natural History Congo Expedition has already been dealt with, and the report will appear elsewhere. Mr. H. K. Munro, of Pretoria, South Africa, has forwarded his entire collection with the request that it be worked over, since very few of the species were determined. Dr. Guy A. K. Marshall, Director of the Imperial Bureau of Entomology, has also been kind enough to forward a large amount of material, and a great deal more has been promised from other sources. It was originally intended to prepare a synopsis of the South African TACHINIDAE preparatory to a more detailed study. However, the large number of species and genera represented in the thousands of specimens at hand makes such an undertaking so extensive that it is deemed advisable to report upon certain genera or larger groups in order that most of the material may be returned to the owners, retaining such specimens as may be necessary for further study.

It is found, when one deals with extensive collections from all parts of the world, that the generic limits of the TACHINIDAE become so indefinite and so hard to define that it is difficult to reconcile the large number of genera, established upon characters of little evident value, with the facts demonstrated by the insects found in such collections. There are many characters used for generic separation which are quite variable within a genus or even in the same species. The fact that some veins of the wings are bristled is certainly not a character of sufficient importance to warrant its use as a basis for generic separation, although such a character may, at times, be conveniently used for the separation of certain genera which display other characters of greater stability.

The reason for the systematic study of insects, or perhaps one should say for Systematic Entomology, is to be found in the desire of man to arrange the things in nature according to his concepts of their relationships. But in Entomology particularly we find ourselves too poorly equipped, too ignorant of the many and varied phases of insect life and insect activities to make, at the present time, even a system which will satisfy ourselves. And the demand which has arisen in recent years owing to the recognition of the value of insect parasites in combating other insects has, to a great extent, changed the duties of systematic entomologists. These men, who previously devoted their time to the subject because of their love for the hobby, are now called upon to determine insects in order that certain forms known to be beneficial may be utilised against injurious species, and for this reason it becomes most necessary that the determination of the various forms of more than usual economic importance be made as simple as possible. In order to arrive at simplicity it will possibly be necessary to sacrifice something of the true "system" or natural arrangement, especially in the preparation of keys. Moreover, it now becomes obvious that the reliable determination of species may be a very important matter, particularly in the case of those which are known to be parasites of insect pests.

From an extensive study it seems clear that the easiest road to the determination of the many species of TACHINIDAE is through fewer genera, based upon characters which can be readily interpreted and which show a degree of stability consistent with our concepts of the generic field. It has been found that the characters used to

separate many genera are evanescent and that, were one to continue using them, species which are obviously closely related would be placed in different, widely separated genera or even in different subfamilies. One fact that stands out in the study of the Tachinid fauna of the world is that there is evidently not a single character which is constant and entirely reliable for the separation of subfamilies or other major groups. We can, of course, recognise certain genera and limit groups of species because of the possession in common of certain characters, but it must be confessed that in the great majority of cases the actual separation of genera is hopelessly weak. It is because of this very weakness that we have so many genera in this family, and one must either study the group with the idea of determining the relationships of the species and genera from the standpoint of the possession of certain characters considered of major importance, resulting in a moderate number of fairly easily definable genera, or assume the attitude that each obvious character is of major importance and thus create an endless number of genera, ultimately arriving at the absurd position of having a genus for practically every species.

In the descriptions of the species certain terminology is employed that may need some explanation. Most of the terms will be familiar to any who have studied the Muscoidea, but some of the characters used will be unfamiliar to the great majority. Some of these likely to be misinterpreted are enumerated here with explanations.

*Propleura hairy in middle.* The median depressed portion of the propleura often bears fine hairs.

*Infra-squamal spinules or setulae.* There may be several short, rather fine hairs or setulae on the slopes of the metanotum below the inner end of the lower squamal lobe.

*Width of front.* This is measured at the narrowest point above the antennae.

*Width of eye.* This is measured across the greatest width of the eye, not from direct frontal or dorsal view.

*Width of parafrontal.* Measured at the narrowest part, but never above the upper fourth of the front.

*Width of frontal vitta.* Measured at the narrowest point if narrowed anteriorly, but usually at the upper third or fourth of the front.

*Parafrontals.* The sides of the front outside the usually opaque frontal vitta.

*Parafacials.* The sides of the face outside the ptilinal suture. Their width, when not notably narrowed below, is measured at the middle.

*Orbital bristles.* Outstanding bristles on the parafrontals outside the frontal row of bristles, which are situated very close to the inner edge of the parafrontals. The orbitals and frontals are normally paired.

*Sublateral bristles.* These include the row of bristles situated in front of the suture immediately outside the dorso-central bristles, the anterior two of which are situated in front just inside the humeri, the latter in front of the intra-alar bristles, which are situated behind the suture. The anterior two sublaterals have frequently been considered part of the posthumeral series of bristles, but this term is here restricted to the bristle situated outside the pre-sutural and behind the humerus. Stein calls the sublaterals the "pre-sutural intra-alars," but the term is cumbersome.

*Marginal bristles.* This term, unless qualified by some other statement, indicates bristles on the dorsum of the abdomen situated on or close to the posterior margin of the segments.

*Discal bristles.* This term indicates bristles situated on the disc of the dorsal portion of the abdominal tergites in front of the marginals.

*Epaulet.* The basal scale on the costa of the wing.



It should be pointed out that there are usually marginal bristles on the sides of the abdomen and sometimes discals, but these are seldom mentioned and are not indicated unless the term *lateral marginals* or *lateral discals* is used.

### **Actia**, Desvoidy.

The species of *Actia* are all small, usually partly, sometimes almost wholly, pale rusty yellowish in colour and more or less thickly pollinose, the pollen usually forming basal fasciae on the abdominal segments. The bristles on the disc of the mesonotum are smaller than the lateral ones and appressed, a character found in but few genera. The antennae are large, the third segment often very large in the male, and the penultimate arisal segment varies in length from little longer than wide to four times as long as wide. The wings show a great deal of variation both in venation and in the bristling of the veins, and some of the species have these organs quite broad and short. The adults are found commonly in long grass and in grassy clearings in woods, particularly sandy places. The larvae are parasitic upon Lepidopterous larvae.

- |     |  |     |     |     |   |    |
|-----|--|-----|-----|-----|---|----|
| 1.  | First vein bristled on at least the apical third   | ... | ... | ... | ...   | 2  |
|     | Only the third vein bristled   | ... | ... | ... | <i>heterochaeta</i> , Bezzi.                            |    |
| 2.  | Fifth vein bristled; apical section of first vein bristled beneath   | ... | ... | ... | ...   | 3  |
|     | Fifth vein bare; first vein rarely bristled beneath  | ... | ... | ... | ...   | 10 |
| 3.  | First vein bristled on practically its whole length  | ... | ... | ... | ...   | 4  |
|     | First vein bristled on apical third only   | ... | ... | ... | <i>normula</i> , sp. n.                                 |    |
| 4.  | Apical cross-vein present  | ... | ... | ... | ...   | 5  |
|     | Apical cross-vein absent; palpi much swollen; ultimate section of fifth vein as long as preceding section                    | ... | ... | ... | <i>munroi</i> , sp. n.                                  |    |
| 5.  | At least the anterior femora wholly pale   | ... | ... | ... | ...   | 6  |
|     | Legs black, coxae yellowish, the anterior femora and tibiae yellowish below  | ... | ... | ... | <i>rejecta</i> , Bezzi.                                 |    |
| 6.  | Tibiae mostly pale in ground-colour  | ... | ... | ... | ...   | 7  |
|     | Tibiae and tarsi black, the femora all pale  | ... | ... | ... | <i>chrysocera</i> , Bezzi.                              |    |
| 7.  | Two strong sternopleurals and a much weaker one below; third antennal segment almost wholly reddish                          | ... | ... | ... | ...   | 8  |
|     | Three strong sternopleurals; third antennal segment mostly blackish  | ... | ... | ... | <i>varichaeta</i> , Curran.                             |    |
| 8.  | Thorax wholly pale, the mesonotum but little darker than the pleura  | ... | ... | ... | ...   | 9  |
|     | Mesonotum and part of the pleura blackish in ground-colour   | ... | ... | ... | <i>cibdella</i> , Villen.                               |    |
| 9.  | Abdomen with incisures and interrupted median vitta brown; setae on underside of first vein much weaker than the dorsal ones | ... | ... | ... | <i>*languidula</i> , Villen.                            |    |
|     | Abdomen wholly pale; ventral setae practically as strong as dorsal ones  | ... | ... | ... | <i>pallens</i> , sp. n.                                 |    |
| 10. | Mesonotum wholly, almost evenly pollinose  | ... | ... | ... | ...   | 11 |
|     | Mesonotum shining black with pale pollinose pattern  | ... | ... | ... | <i>spoliata</i> , Bezzi.                                |    |
| 11. | First vein without bristles below  | ... | ... | ... | ...   | 12 |
|     | First vein with several setae below apically...  | ... | ... | ... | <i>mitis</i> , sp. n.                                   |    |
| 12. | First vein bristled from the humeral cross-vein to apex  | ... | ... | ... | ...   | 14 |
|     | First vein bare on basal two-thirds  | ... | ... | ... | ...   | 13 |
| 13. | Posterior cross-vein situated near the middle of the penultimate section of the fourth vein                                  | ... | ... | ... | <i>lavinia</i> , sp. n.                                 |    |
|     | Posterior cross-vein much nearer the anterior cross-vein than the bend of the fourth vein                                    | ... | ... | ... | <i>compacta</i> , sp. n.                                |    |
| 14. | Legs black   | ... | ... | ... | ...   |    |
|     | Legs reddish   | ... | ... | ... | <i>nigripes</i> , Curran.<br><i>natalensis</i> , sp. n. |    |

\* Not seen, and colour of mesonotum doubtful. The fifth vein is ciliate only about half-way to the posterior cross-vein.



***Actia normula*, sp. n.**

Yellowish and pale rusty reddish, the mesonotum and part of the pleura black. Length, 6 mm.

♂. *Head* pale yellow, white pollinose, the front with yellowish tinge above; occiput mostly black above the neck; bristles strong. Bristly hair below the neck yellowish. Width of cheeks equal to one-fourth the eye-height. Palpi pale orange, swollen on the apical half. Antennae reddish yellow, the third segment in large part pale brownish, wide, a little more than twice as long as wide, subtruncate apically. Arista black on the apical half, short pubescent, the penultimate segment three times as long as wide. *Thorax* densely cinereous yellow pollinose; humeri, sides of mesonotum, scutellum and most of the pleura, yellowish in ground-colour. Four pairs of post-sutural dorso-central bristles; three sternopleurals, the anterior two weaker than the posterior one. *Legs* reddish, the tips of the posterior femora and all the tarsi, brown. *Wings* cinereous hyaline; venation normal; first vein bristled on the apical third above; third vein bristled on almost its whole length, the fifth almost halfway to the posterior cross-vein. Squamae whitish. Halteres pale yellow. *Abdomen* with a median vitta composed of long, narrow, weakly separated, brown triangles; third segment with a broad, posterior transverse brown spot laterally. Bases of apical three segments rather broadly densely whitish pollinose, the pollen elsewhere less dense and leaving the broad segmental apices and a median vitta bare.

*Type*, ♂, paratype, ♂, East London, Cape Province, South Africa, 7 and 9.v.1923 respectively (*H. K. Munro*). Type in Mr. Munro's collection.

***Actia munroi*, sp. n.**

Related to *A. lamia*, Meigen, but at once distinguished by the orange palpi and the fact that all the bristles on the first vein are equally strong. Length, 5.25 mm.

♀. *Head* pale yellow, the occiput black above the neck, whitish pollinose, the front with yellowish pollen which merges into white below; frontal vitta slightly wider than parafrontal, rusty reddish yellow; bristles strong. Cheeks a little more than one-third as wide as eye-height. Antennae reddish, the third segment mostly brown, narrow, four times as long as wide, the lower apex rounded; arista brown on apical half, very weakly pubescent, its penultimate segment two and one-half times as long as wide. *Thorax* blackish, densely cinereous yellowish pollinose; humeri, narrow lateral margins and the scutellum, yellow in ground-colour, the pleura reddish brown and in part yellowish. Four pairs of post-sutural dorso-centrals and three sternopleurals. *Legs* short and rather robust, reddish, the posterior pair ferruginous, the apical half of the middle femora ferruginous above; tarsi brown, the anterior pair not swollen. *Wings* cinereous hyaline; first vein bristled on its whole length, the third on its basal half, the fifth half-way to the posterior cross-vein; fourth vein obsolete beyond the bend; posterior cross-vein oblique, its anterior end behind the tip of the first vein, the ultimate section of the fifth vein decidedly longer than the preceding section. *Abdomen* black; mostly reddish below and also on the sides of the first segment and basal third of the second. Bases of second to fourth segments narrowly densely whitish pollinose, the dorsum entirely thinly so; apices of first to third segments narrowly yellow. First segment without bristles, the second with a pair of strong marginals.

*Type*, ♀, Barberton, South Africa, 8.x.1919 (*H. K. Munro*).

***Actia pallens*, sp. n.**

Wholly pale rusty yellow, except that the upper half of the occiput is brown. Length, 4.5 mm.

♀. *Head* pale yellow, white pollinose; frontal vitta pale orange, one and one-half times as wide as parafrontal at middle; bristles strong. Cheeks one-fourth as wide

as eye-height. Proboscis and palpi yellow. Antennae reddish, the third segment largely reddish brown, broad, about three times as long as wide, its apex obtusely rounded; arista short pubescent, brownish on apical half, its penultimate segment hardly three times as long as wide. *Thorax* thickly pale cinereous pollinose; four pairs of post-sutural dorso-centrals; three sternopleurals, the lowest one weakest. *Legs* simple; tarsi brown. *Wings* cinereous hyaline; first vein bristled on its whole length, the third to its apical fifth, the fifth almost to the posterior cross-vein. Venation normal. Squamae whitish. Halteres pale yellowish. *Abdomen* with pollen quite thin, evident only from posterior view. First segment without bristles.

*Type*, ♀, Durban, Natal, 18.x.1919; in the collection of the Division of Entomology, Pretoria.

### **Actia cibdella**, Vill.

Mesonotum black; legs yellowish; first, third and fifth veins bristled, the first on almost its whole length, the third on most of its length, all the bristles strong; first vein bristled on lower surface apically, the third with a single strong basal bristle below. Length, 4.5 to 5 mm.

♂. *Head* pale yellow, densely dull whitish pollinose, the occiput mostly black on the upper half, the broad frontal vitta dull orange; bristles strong; cheeks one-third as wide as eye-height. Palpi broadened and flattened on the apical half, reddish yellow. Antennae orange, the third segment large, two and one-fourth as long as wide, with almost parallel sides, its apex obtuse, rounded below; penultimate arisal segment about three times as long as wide, the arista conspicuously pubescent. *Thorax* black, the pleura sometimes largely luteous, the scutellum translucent yellowish, darker dorsally; pollen cinereous, very dense. Four pairs of post-sutural dorso-centrals; three sternopleurals, the lowest one weak but long. *Legs* reddish yellow, the tarsi brownish; posterior femora narrowly brown above and apically. *Abdomen* reddish yellow; a broad median vitta and the dorsal surface of the third and fourth segments, except the broad base of the former laterally, blackish. Second to fourth segments each with a narrow, white pollinose basal fascia, the pollen elsewhere only appearing dense from posterior view. First segment without dorsal bristles, the second with a pair of strong marginals.

♀. Third antennal segment about three times as long as wide.

♂, Yaba, S. Nigeria (*W. Graham*); 4 ♂♂, 6 ♀♀ Lourenço Marques, Portuguese East Africa, 1921 (*C. B. Hardenberg*); and ♂, Barberton, 22.v.1913 (*H. K. Munro*).

### **Actia mitis**, sp. n.

First and third veins bristled above and below; ultimate section of the fifth vein as long as the preceding section. Length, 3.25 mm.

♂. *Head* pale yellow, white pollinose, the occiput mostly black; frontal vitta rusty yellow, one and one-fourth as wide as parafrenal at middle; bristles strong. Cheeks hardly one-fourth as wide as eye-height. Proboscis brownish red, the palpi light yellow. Basal two antennal segments yellowish, the third blackish, moderately wide, three times as long as wide, angular above, rounded below at apex; arista brown, pubescent, the penultimate segment not three times as long as wide. *Thorax* black, densely ashy pollinose, the border of the scutellum narrowly pale yellow on the apical half. Bristles of the mesonotum unusually weak; four post-sutural dorso-centrals; three sternopleurals. *Legs* reddish, the tarsi brown. *Wings* cinereous hyaline; apical section of the first vein bristled above and below, the dorsal bristles fine; third vein bristled on the basal half; posterior cross-vein oblique, situated near the middle of the wing. Squamae whitish. Halteres pale yellow. *Abdomen* shining brownish, the sides of the first segment on the basal two-thirds, the narrow apices of the segments and the lower surface medianly, yellowish. Broad

bases of segments two to four broadly yellowish white pollinose, the median vitta and broad segmental apices quite bare. First segment without dorsal bristles, the second with a moderately strong pair of marginals.

*Types*, ♂♀, Barberton, South Africa, 15.v.1913 (*H. K. Munro*); in Munro collection. Paratype, ♂, Barberton, 17.v.1913.

The female shows only normal sexual differences, the palpi being strongly swollen apically, the 2nd aristal segment shorter, the 3rd antennal segment also shorter than in the ♂.

### ***Actia lavinia*, sp. n.**

Reddish yellow, the mesonotum, upper half of the occiput and abdominal markings, blackish. Length, 6.5 mm.

♀. *Head* densely whitish pollinose; frontal vitta reddish, one and one-half times as wide as parafrontal at middle; bristles strong. Cheeks one-fifth as wide as eye-height. Proboscis brownish. Palpi reddish yellow, moderately swollen apically. Antennae reddish, the third segment partly brownish red, large, three times as long as wide, obtusely rounded apically; arista pubescent, darkened on its apical third, the penultimate segment twice as long as wide. *Thorax* densely pale cinereous pollinose, the humeri, sides of the mesonotum, scutellum and pleura, pale yellow. Four pairs of post-sutural dorso-central bristles; three sternopleurals, the lowest weak. *Legs* reddish yellow; tarsi blackish; front legs missing. *Wings* cinereous hyaline; venation normal; posterior cross-vein midway between the anterior cross-vein and bend of fourth vein; third vein bristled almost to the posterior cross-vein; fifth vein bare. *Abdomen* with a median vitta on the first and fourth segments, the posterior third of the second and third segments blackish, expanded in the middle almost to the base of the segments, the whitish pollen rather dense, forming broad basal fasciae on segments two to four. First segment without dorsal bristles, the second with a pair of rather weak marginals.

*Type*, ♀, Clan Syndicate, Natal, 24.iv.1914, in collection of Division of Entomology, Pretoria; paratype, ♀, New Hanover, Natal, 5.iv.1916 (*G. C. Haines*), in Curran collection.

The paratype has the abdomen wholly pale.

### ***Actia compacta*, sp. n.**

Black and rusty yellowish; a small, rather robust species with short, broad wings. Length, 3.75 mm.

♂. *Head* pale yellow, white pollinose, the front and orbits above with dull ochreous pollen; occiput partly black. Cheeks one-fifth as wide as eye-height. Proboscis brown, a little elongate; labella pale yellow. Palpi yellow, rather strongly broadened on the apical third. Antennae reddish, the third segment mostly brownish, three times as long as wide, obtusely rounded apically; arista mostly brownish, pubescent, the penultimate segment three times as long as wide. *Thorax* with the humeri, free border of the scutellum and about half the pleura, pale yellow; thorax densely yellowish pollinose above, whitish on the pleura. Three pairs of post-sutural dorso-central bristles; three sternopleurals. *Legs* reddish; posterior femora dorsally and apically and the tarsi, brown; middle femora somewhat darkened apically. *Wings* short and broad; posterior cross-vein situated conspicuously closer to the small cross-vein than to the bend of the fourth vein, the ultimate section of the fifth vein only a little more than half as long as the preceding section. First vein with fine hair-like bristles on the apical third, the third with strong bristles on almost the basal half. Squamae and halteres pale yellowish. *Abdomen* with the second abdominal segment on its posterior half (narrowed towards the middle), the third on its posterior fourth (narrowed to half towards the middle), the fourth except the



broad base, shining brownish black; bases of apical three segments broadly white pollinose. First segment without dorsal bristles, the second with a pair of very strong marginals.

*Type*, ♂, East London, Cape Province, South Africa, 8.v.1923 (*H. K. Munro*), in *Munro* collection.

### ***Actia natalensis*, sp. n.**

Wholly dull rusty yellowish or luteous, the apical segment of the anterior tarsi brownish; first vein bristled above on its whole length, bare below; third vein bristled to the anterior cross-vein, with about three basal bristles below. Length, 4.5 mm.

♂. *Head* pale yellow on the lower half, thickly white pollinose except the frontal vitta, which is twice as wide as either parafrontal at the middle. Cheeks not one-third as wide as eye-height. Palpi clavate. Antennae orange, the third segment broad, two and one-half times as long as wide, slightly narrowed on the basal half, the apex obtuse; arista apparently bare, the penultimate segment two and one-half as long as wide. *Thorax* rather thickly cinereous pollinose, the dorsum somewhat darker in ground-colour. Three pairs of posterior dorso-centrals; three sternopleurals, the lowest weakest. *Legs* simple. *Wings* cinereous hyaline; apical cell narrowly open near the apex of the wing. Squamae and halteres pale yellowish. *Abdomen* with a slight brownish-red tinge on the middle line and the apical two or three segments dorsally, the segmental apices pale yellow. Bases of segments two to four rather broadly densely white pollinose, the whole surface rather thinly pollinose from posterior view except for the spots from which the hairs arise.

♀. The apical three segments of the anterior tarsi are considerably broadened and thickened, the apical segment unusually long and brown in colour; penultimate arisal segment about one and one-half as long as wide; third antennal segment narrower, three times as long as wide.

*Type*, ♂, allotype, ♀, and 5 ♂♂, 5 ♀♀ paratypes, Cramond, Natal, 29.iii.1913, in collection of Division of Entomology, Pretoria. Paratypes in British Museum.

### ***Actia varichaeta*, Curran.**

This species was described from two specimens, one from the Belgian Congo, the other Cape Province, South Africa. The first vein bears two types of bristles above, those on the apical section being much shorter and finer.

At the time of writing the descriptions of this and the following species have not appeared but will be published in "American Museum Novitates" early in 1927.

### ***Actia nigripes*, Curran.**

Original description based on a single male from Boma, Belgian Congo. The legs are wholly black and the bristles on the apical section of the first vein are somewhat finer than the basal ones.

### ***Zenillia* Desvoidy.**

*Zenillia*, Desvoidy, *Myodaires*, p. 152, 1830.

*Phryxe*, Desvoidy, *t.c.*, p. 158.

*Carcelia*, Desvoidy, *t.c.*, p. 176.

*Aplomya*, Desvoidy, *t.c.*, p. 184.

*Hubneria*, Desvoidy, *Ann. Soc. Ent. France*, p. 601, 1847.

*Chetoliga*, Rondani, *Dipt. Ital. Prod.*, i, p. 66, 1856.

*Blepharidea*, Rondani, *t.c.*, p. 67.

*Paraexorista*, Brauer & Bergenstamm, *Denkschr. Akad. Wien*, lvi, p. 87, 1889.



- Alsomyia*, Brauer & Bergenstamm, *op. cit.*, lviii, p. 328, 1891.  
*Thelymyia*, Brauer & Bergenstamm, *t.c.*, p. 330.  
*Myxexorista*, Brauer & Bergenstamm, *t.c.*, p. 331.  
*Catagonia*, Brauer & Bergenstamm, *t.c.*, p. 348.  
*Eusisyropa*, Townsend, Smiths. Misc. Coll., li, p. 97, 1908.  
*Oxexorista*, Townsend, Proc. Ent. Soc. Wash., xiv, p. 165, 1912.  
*Euxorista*, Townsend, *t.c.*, p. 166.  
*Chrysomasicera*, Townsend, Jl. N.Y. Ent. Soc., xxiii, p. 230, 1915.  
*Chrysoexorista*, Townsend, Proc. U.S. Nat. Mus., xlix, p. 435, 1915.  
*Prozenillia*, Villeneuve, Ann. S. Afr. Mus., xv, p. 487, 1916.  
*Prooppia*, Townsend, Insec. Ins. Mens., xiv, p. 32, 1926.  
*Plagiophryxe*, Townsend, *t.c.*, p. 32.  
*Exorista*, auctt. (not Mg.).

Most of the above synonymy has been given by Aldrich & Webber.\* Additional synonymy will be found in the "Katalog der Paläarktischen Dipteren." I have added some names which are placed differently in the Palaearctic catalogue. These so-called genera are based upon evanescent characters and the union into one comprehensive genus should simplify the determination of the species.

### Key to Species.

1. Metallic green or blue ; thorax and abdomen without pale pollen. *insolita*, Curran  
 Blackish, parts of abdomen and scutellum often more or less reddish ... 2
2. Sternopleurals 1-1 ... .. 3  
 3 or 4 sternopleurals ... .. 10
3. ♀ with strong piercing ovipositor ... .. *devastator*, Curran  
 ♀ without piercing ovipositor ... .. 4
4. Ocellar bristles long ... .. 5  
 Ocellars scarcely differentiated ... .. *fuscicosta*, Curran
5. Palpi black ... .. *pilipes*, Villen.  
 Palpi reddish ... .. 6
6. Middle of abdomen with long, erect bristly hairs, among which are usually distinct discals on second and third segments ... .. *subdistincta*, Villen.  
 Abdomen with the hair appressed on intermediate segments or not unusually long ; discals never present ... .. 7
7. Third antennal segment about twice as long as second ; hind tibiae closely ciliate ... .. 8  
 Third antennal segment at least three times as long as second ; hind tibiae rather sparsely ciliate... .. 9
8. Epaulet brown ... .. *evolans*, Wied.  
 Epaulet reddish ... .. *illota*, sp. n.
9. Third antennal segment five or six times as long as second *argyriceps*, sp. n.  
 Third antennal segment about three times as long as second ... .. *norma*, sp. n.
10. Sternopleurals 2-1 ... .. 11  
 Sternopleurals 2-1-1 or 2-2 ... .. 20
11. Third antennal segment at least three and one-half times as long as second 12  
 Third antennal segment not more than three times as long as second ... 18
12. Face, on lower part, distinctly convex in profile ; facial ridges often bristled on lower third or more ... .. 14  
 Face straight or nearly so, the vibrissal angles more or less prominent ... 13

\* Proc. U.S.N.M., lxiii, Art. 17, 1924.

13. Third antennal segment five or six times as long as second ; its base usually  
conspicuously convex above ... .. *angulicornis*, Villen.  
Third antennal segment less than four times as long as second, not convex above  
basally ... .. *normula*, sp. n.
14. Third vein with two to four basal bristles ... .. 15  
Third vein with bristles extending over half way to the small cross-vein.  
... .. *vexor*, sp. n.
15. Facial ridges bristly on about the lower half ... .. 16  
Facial ridges bristly on less than the lowest fourth... .. 17
16. ♂ with three pairs of reclinate orbitals ; fourth abdominal segment pollinose on  
basal half ... .. *orbitalis*, sp. n.  
♂ with two proclinate orbitals ; fourth abdominal segment pollinose on less than  
basal fourth ... .. *corrupta*, sp. n.
17. ♂ without orbitals ; three or four frontals below base of antennae *vara*, sp. n.  
♂ with two orbitals ; two frontals below base of antennae ... .. *vaga*, sp. n.
18. Facial ridges with sparse bristles on lower third ... .. *sordida*, Villen.  
Facial ridges with bristly hairs on lowest fourth or less ... .. 19
19. Posterior tibiae rather closely ciliate ... .. *tenor*, Curran  
Posterior tibiae with sparse but evenly long bristles antero-dorsally *illita*, Villen.
20. Mesonotum very weakly pollinose in front ; abdomen of ♂ entirely shining black ;  
♂ without orbitals ... .. *poultoni*, Villen.  
Mesonotum thickly pollinose before the suture ; if shining behind, the ♂ abdomen  
is not wholly shining black or the ♂ possesses at least one pair of orbitals 21
21. Mesonotum thickly pollinose behind the suture ... .. 22  
Mesonotum, from posterior view, scarcely pollinose behind the suture ; ♂ with one  
pair of orbitals ... .. *lycaena*, sp. n.
22. Pollen of thorax and abdomen yellowish ; ♂ abdomen wholly shining black  
... .. *versicolor*, sp. n.  
Pollen cinereous ; ♂ with two interrupted pollinose abdominal fasciae  
... .. *distans*, Villen.

### ***Zenillia insoleta*, Curran.**

Described from two males from the Belgian Congo. It is a metallic bluish or greenish species ; the arista long pubescent. It belongs to the subgenus *Alsomyia*, Br. & Berg.

### ***Zenillia devastator*, Curran.**

Described from the Belgian Congo. The female has a long, strong, curved ovipositor. The subgenus *Zenilliana* was proposed for this form.

### ***Zenillia fuscicosta*, Curran.**

Described from the Belgian Congo. The costal border is broadly brown, tapering apically.

### ***Zenillia pilipes*, Villeneuve.**

*Exorista pilipes*, Villeneuve, Ann. S. Afr. Mus., xv, p. 483, 1926.

A ♂, Barberton, South Africa, 25.iv.1920 (*H. K. Munro*).

### ***Zenillia evolans*, Wiedemann.**

*Tachina evolans*, Wiedemann, Ausser. Zweifl., ii, p. 321, 1830.

I have examined the type of this species and have seen many specimens from South Africa and the Belgian Congo. The South African specimens are from East

London, Pretoria and Durban. The species occurs during the whole year. No host records are available in the material before me.

**Zenillia illota**, sp. n.

Closely related to *Z. evolans*, Wiedemann, but the epaulet of the wings is reddish and there are differences in the pupa, while the black abdominal fasciae are narrower. Length, 9 to 10 mm.

♂. *Head* silvery white pollinose; front two-thirds as wide as either eye, the brown vitta narrower than either parafrontal; about eleven pairs of frontal bristles, the lower three below the base of the antennae, the upper two reclinate; frontal hair short and fine; ocellars long; outer verticals absent; no occipital setae; pile whitish; cheeks very narrow, at most one-twentieth as wide as eye-height. Parafacials above about as wide as third antennal segment, hardly half as wide below. Vibrissae level with oral margin, three or four bristles immediately above them. Palpi reddish, broad. Antennae black, reaching almost to the vibrissae, the incisures reddish, the third segment two and one-half as long as the second, fairly broad; arista thickened on hardly the basal half. Eyes densely short cinereous pilose. *Thorax* and scutellum cinereous pollinose, the vittae very narrow but distinct; scutellum reddish yellow except basally. Dorso-centrals, 3-4; sternopleurals, 1-1; four pairs of marginal scutellars, the apical pair weaker and cruciate, horizontal. *Legs* black; pulvilli small, reddish yellow; middle tibiae with one antero-dorsal bristle; posterior tibiae closely ciliate. *Wings* cinereous hyaline, the veins largely luteous, the third vein with three to six bristles basally; bend of fourth vein rather sharp, the apical cell ending moderately before the wing-tip. Squamae white. Halteres reddish. *Abdomen* with the apical three segments cinereous pollinose with the apical fifth or less bare and with an incomplete dark median vitta. First and second segments with moderately developed marginals, the third and fourth each with a row, the latter with discs on the apical third and strong erect hair, the hair elsewhere appressed, but less so medianly.

♀. Front with two pairs of orbitals; face not greatly wider than the front; outer verticals well developed; marginal bristles stronger.

*Type*, ♂, Morogoro, Tanganyika Territory, vii.1923 (*A. H. Ritchie*) ex *Heliothis* sp.; allotype, ♀, Namiwawa, 13.iv.1915 (*C. Mason*) ex *Acontia graelsii* (Lep. Noct.). Paratypes: ♀, same locality and date as type ♂; ♂, same data as allotype except taken on 2.iv.15; ♂♀ Namiwawa (*C. Mason*) ex *Heliothis obsoleta* (Lep. Noct.); ♂, Pretoria, South Africa, 27.iv.1919 (*H. K. Munro*). Types in British Museum.

**Zenillia argyriceps**, sp. n.

Black, the scutellum mostly and the palpi, reddish; whitish pollinose; sternopleurals 1-1; posterior tibiae sparsely ciliate. Length, 8.5 mm.

♂. *Head* silvery-white pollinose, the front with very slight yellowish tinge, eight-elevenths as wide as either eye, the brownish vitta wider than parafrontal at upper two-thirds, slightly narrowed anteriorly; about eleven pairs of frontals, the lower five below the base of the antennae, the upper two reclinate; ocellars well developed; no occipital setae behind the cilia; pile white. Cheeks one-seventh as wide as eye-height; parafacials half as wide as third antennal segment at the middle, narrowing below, broad above. Vibrissae level with oral margin, three or four bristly hairs above them; facial depression fairly deep. Palpi reddish. Antennae black, reaching almost to the vibrissae; third segment broad, five times as long as the second; arista thickened on the basal fourth. *Thorax* whitish pollinose, the vittae narrow, distinct. Dorso-centrals, 3-4; 4 pairs of marginal scutellars, the apical pair cruciate. *Legs* black; pulvilli luteous, long; middle tibiae with one antero-dorsal bristle; posterior tibiae sparsely ciliate. *Wings* cinereous hyaline; third vein with three or four setae basally; bend of fourth vein sharp, the apical cross-vein bowed inwards near its base,



ending well before the wing-tip; posterior cross-vein joining the fourth vein near the apical fourth of its penultimate section. Squamae white. Halteres reddish, with brown knob. *Abdomen* with the apical three segments moderately whitish pollinose, the apical fifth of the second and third and apical fourth of the fourth segments dark, a slender, more or less distinct median dark vitta. First segment with a pair of small, the second with large marginals, the third and fourth each with a row, the latter with a row of discals on the apical half. Hair appressed, erect on the fourth segment.

*Type*, ♂, Kizazi, Kinkizi Co., Uganda, x.1922 (*H. Hargreaves*).

The projection of the front is rather strong in this species.

### ***Zenillia norma*, sp. n.**

Head silvery white pollinose, the brownish frontal vitta at its upper third about as wide as either parafrontal; antennal prominence produced, the distance from its apex to the eye equal to almost twice the width of the third antennal segment. Black, with whitish pollen; sternopleurals, 1-1. Length, 9 mm.

♂. *Head* with front four-fifths as wide as either eye; no orbitals; about ten pairs of frontals, two below the base of the antennae, the upper two reclinate; outer verticals absent; no occipital setae behind the cilia; pile whitish. Cheeks one-eighth as wide as eye-height; parafacials wide, largely yellowish in ground-colour, narrowed below. Vibrissae level with oral margin, a few bristly hairs above them. Palpi reddish. Antennae black, the third segment moderately narrow, a little over three times as long as the second; arista thickened on the basal half. *Thorax* with rather whitish pollen, but somewhat luteous-tinged dorsally and the four vittae brownish. Dorsocentrals, 3-4; 4 pairs of marginal scutellars, the weaker apical pair cruciate. Scutellum reddish on the apical half. *Legs* black; pulvilli luteous, elongate; middle tibiae with one antero-dorsal bristle; posterior tibiae sparsely ciliate. *Wings* cinereous hyaline; apical cell ending moderately far before the wing-tip; posterior cross-vein joining the fourth vein near the apical third of its penultimate section, the bend of the fourth vein rather sharp, the cross-vein almost straight; third vein with three basal bristles. Squamae white. Halteres brown, with reddish base. *Abdomen* black; basal two-thirds, widened to three-fourths at the sides, of the second segment, one-third of the third and half of the fourth, cinereous pollinose, the broad apices of the second to fourth segments with brownish pollen, the pale pollen less dense immediately in front of the brown bands except laterally and there is a more or less distinct slender median dark vitta. First and second segments each with a pair of marginals, the third and fourth each with a row, the fourth with a row of discals on the apical third. Hair appressed; erect on the fourth segment.

*Type*, ♂, Bugoma Forest, Uganda, 17.vi.1910 (*C. C. Gowdey*), in the British Museum.

### ***Zenillia angulicornis*, Villeneuve.**

*Carcelia angulicornis*, Villeneuve, Ann. S. Afr. Mus., xv, p. 481, 1915.

Two males collected by H. K. Munro at Barberton, 23.viii.1924, and East London, 10.iii.1923.

The second specimen does not show the strongly convex base of the third antennal segment owing to drying, and the character is hardly reliable.

### ***Zenillia normula*, sp. n.**

Evidently a true *Zenillia* but extremely similar in appearance to *Z. vaga*. It differs from *vaga* in having the profile of the parafacials almost straight and the second antennal segment a little longer. Otherwise it agrees in all respects in the ♀. The



pupal characters are very distinctive. In *vaga* the posterior respiratory organs are but little raised, while in *normula* they project a distance equal to half their greatest width.

The ♂ differs from *vaga* in the absence of orbitals, and the frontal vitta is about as wide as either parafrontal, the front three-fifths as wide as either eye; about ten pairs of frontals, four below the base of the antennae, the upper two reclinate; outer verticals absent; no setae behind the cilia.

*Type*, ♀, Rosaka, Uganda, 30.iv.1923 (*H. Hargreaves*) ex *Acraea acerata*; allotype, ♂, Kampala, Uganda, 17.xi.1915 (*C. C. Gowdey*). Types in the British Museum.

### ***Zenillia vexor*, sp. n.**

Parafacials convex in profile below; third vein setulose more than half-way to the small cross-vein; fourth vein with trace of an appendage at the bend. Black, with cinereous or whitish pollen. Length, 5 mm.

♂. *Head* whitish pollinose, the front rather thinly so above, somewhat narrower than either eye, the face strongly widened; frontal vitta with almost parallel sides, brownish, hardly as wide as parafrontal at upper third. Seven pairs of strong frontals, three below the base of the antennae, the upper two reclinate, the three above the base of the antennae diverging in position upwardly, the upper one not in line with the others; outside the frontal row are three rather strong secondary ones below the middle of the front; no orbitals; ocellars and outer verticals rather weak; no occipital setulae behind the cilia. Pile cinereous. Cheeks one-twelfth as wide as eye-height; parafacials very narrow below, four or five times as wide above. Vibrissae level with the oral margin, the ridges with weak bristles on the lowest fifth. Palpi reddish. Antennae black, broad, reaching almost to the vibrissae, the third segment six times as long as the second; penultimate arisal segment short, the arista thickened on hardly the basal half. *Thorax* moderately cinereous pollinose, rather shining above, the vittae not conspicuous. Dorso-centrals, 3-4; sterno-pleurals, 2-1; 4 pairs of marginal scutellars, the apical pair weaker and cruciate. Scutellum broadly reddish apically. *Legs* black; pulvilli very small; middle tibiae with a single antero-dorsal bristle; posterior tibiae antero-dorsally with a row of equally spaced evenly long bristles. *Wings* cinereous hyaline; squamae white; halteres brown, with reddish base. *Abdomen* shining black, the second and following segments each with about the basal third white pollinose, the pollen poorly defined posteriorly. First and second segments each with a pair of long, rather fine marginals, the third and fourth each with a row, the latter with a row of discals. Hair appressed, not abundant.

*Type*, ♂ and ♂ paratype, Durban, Natal, 22.vi.1920. Type in collection of Division of Entomology, Pretoria.

### ***Zenillia orbitalis*, sp. n.**

Belongs to the subgenus *Thelymyia*, Br. & Berg., and agrees with *Z. corrupta* except as follows:—

Length, 7 mm. ♂. Three pairs of strong reclinate orbitals, the six pairs of frontals becoming very weak above, two or three below the base of the antennae; outer verticals weaker. Third antennal segment broader, five or six times as long as the second; arista thickened on the basal third; apex of the scutellum broadly, distinctly reddish; pulvilli brown; basal half or more of the apical three abdominal segments moderately cinereous pollinose, sub-tessellate; erect abdominal hair longer but not as coarse.

*Type*, ♂, Pretoria, South Africa, 18.i.1918 (*H. K. Munro*), in Munro collection.

The female of this species will probably be distinguished from *corrupta* in having the third antennal segment wider, broadly reddish scutellar apex and the basal half of the fourth abdominal segment pollinose.

***Zenillia corrupta*, sp. n.**

Belongs to the subgenus *Thelymyia*, Br. & Berg. ; differs from *vaga* in having two or three antero-dorsal bristles on the middle tibiae and the facial ridges with bristles on the lower half. Length, 6 mm.

♂. *Head* silvery white pollinose, less white on the front which is almost three-fourths as wide as either eye, the inner orbits slightly diverging from vertex to lower ends of eyes ; frontal vitta reddish, not as wide as para-frontal at upper third ; about eight pairs of frontals, the upper one reclinate, the lower two below the base of the antennae ; two pairs of strong proclinate orbitals ; ocellars strong ; outer verticals over half as long as verticals ; no occipital setulae behind the cilia ; pile whitish. Cheeks one-eighth as wide as eye-height ; parafacials above about as wide as third antennal segment, one-fifth as wide below ; vibrissae level with oral margin, the ridges convex below when viewed in profile, bristled on the lower half. Palpi reddish. Antennae black, reaching almost to the vibrissae, the third segment broad, convex above basally, about four and one-half times as long as the second ; arista thickened on almost the basal third. Eyes thickly cinereous pilose. *Thorax* cinereous pollinose, the vittae not conspicuous. Dorso-centrals, 3-4 ; sternopleurals, 2-1 ; four pairs of marginal scutellars, the apical weak pair cruciate, almost horizontal, the scutellum very obscurely reddish apically, the hairs short, stout, bristly, erect. *Legs* black ; pulvilli luteous, small ; middle tibiae with a long antero-dorsal bristle before the middle and a weaker one before and beyond it ; posterior tibiae rather sparsely long ciliate. *Wings* cinereous hyaline ; bend of fourth vein moderately sharp, the apical cell ending well before the wing-tip ; third vein with two basal bristles. Squamae white. Halteres reddish with brown knob. *Abdomen* wholly black ; first and fourth segments without pollen, the second and third each with the basal third, somewhat widened in the middle, whitish pollinose, more conspicuously so basally. First segment with short weak pair, the second with strong pair of marginals, the third and fourth each with a row, the hair on the middle of the second and third segments and the whole of the fourth segment, coarse and bristly, erect, elsewhere appressed, the broad apex of the third segment and the whole of the fourth highly shining.

♀. Quite similar, but the pile of the eyes shorter, and the basal fourth of the fourth abdominal segment is thinly pollinose.

*Holotype*, ♂, allotype, ♀, Jeza, Uganda, ii.1921 (*H. Hargreaves*), ex Syrphid.

This appears to be a new host record for the TACHINIDAE. I know of no other record of Tachinids being parasitic on other Diptera.

***Zenillia vara*, sp. n.**

Small, black, cinereous pollinose ; face in profile convex below ; antennae long. Length, 6 to 7 mm.

♂. *Head* silvery-white pollinose, the front less thickly so, almost three-fourths as wide as either eye, the face rather narrow ; about nine pairs of frontals, three below the base of the antennae, the three upper pairs reclinate ; frontal hair fairly abundant ; ocellars long, somewhat divergent ; outer verticals half as long as verticals ; frontal vitta brown, almost as wide as either parafrontal ; no occipital setulae behind the cilia ; pile cinereous. Cheeks one-twentieth as wide as eye-height ; parafacials above much narrower than third antennal segment, tapering below. Vibrissae level with oral margin, the ridges with four or five bristles on the lowest fifth ; facial depression

deep. Palpi reddish, broad. Antennae black, reaching almost to the oral margin; third antennal segment five times as long as the second; arista thickened on the basal third to two-fifths. Eyes with short, dense pile. *Thorax* with greyish pollen, that on the mesonotum with brownish tinge in places, the vittae moderately distinct. Dorsocentrals, 3-4, sternopleurals, 2-1; 4 pairs of marginal scutellars, the apical weak pair oblique, cruciate. Scutellum reddish with darker base. *Legs* black; pulvilli long, luteous; middle tibiae with a single antero-dorsal bristle; posterior tibiae sparsely ciliate. *Wings* cinereous hyaline; apical cell ending moderately before the wing-tip, the bend of the fourth vein rather acute; posterior cross-vein gently curved; third vein with two or three basal bristles. Squamae whitish. Halteres reddish, with brown knob. *Abdomen* with the sides of the second and third segments broadly reddish except apically, the apical three segments cinereous pollinose with darker apices which vary slightly in width but are poorly defined and not over one-fifth as wide as the length of the segments. First and second segments each with a pair of fairly strong marginals, the third and fourth each with a row, the fourth with a row of discals and some additional ones laterally. Hair appressed laterally, suberect medianly, erect on the fourth segment.

♀. Front with almost parallel sides, with six to eight pairs of frontals, the upper two reclinate; two pairs of orbitals.

*Type*, ♂, Kabete, Kenya, viii.1914 (castor-oil moth); allotype, ♀, Zanzibar, 7.vii.1916 (*Dr. W. M. Aders*), ex *Porthesia producta* (Lep. Lymant.). Paratypes: ♂, same data as type; 3 ♀♀, same data as allotype.

### **Zenillia vaga, sp. n.**

Belongs to the subgenus *Thelymyia*, Br. & Berg., having two orbitals in the ♂; differs from *T. demens*, Zett., in having the arista thickened on basal third only and in its smaller size. Length, 5 to 5.5 mm.

♂. *Head* silvery-white pollinose; front almost three-fourths as wide as either eye, the brownish vitta narrower than parafrontal; two pairs of strong orbitals; six or seven frontals, the upper two reclinate; ocellars long; outer verticals well developed; no occipital setulae behind the cilia; pile whitish. Cheeks very narrow; parafacials much narrower than third antennal segment, tapering below. Vibrissae level with oral margin, three to five bristles on the lowest fifth of ridges. Palpi reddish, broad. Antennae black, reaching almost to the oral margin; third antennal segment broad, five or six times as long as the second; arista thickened on basal third. *Thorax* cinereous pollinose, with moderately distinct vittae. Dorsocentrals, 3-4; sternopleurals, 2-1; 4 pairs of marginal scutellars, the apical weak pair oblique, cruciate. Scutellum reddish with the basal third or less black. *Legs* black; pulvilli small; middle tibiae with a single antero-dorsal bristle; posterior tibiae sub-ciliate. *Wings* cinereous hyaline, the apical cell ending moderately before the apex of the wing, the bend of the fourth vein rather sharp; third vein with two or three bristles basally. Squamae white. Halteres reddish, with brown knob. *Abdomen* with the sides of the second and third segments reddish except apically, the apical three segments moderately cinereous pollinose, the rather broad apices bare. First and second segments each with a pair of strong marginals, the third and fourth with row, the fourth with a row of discals and some additional ones towards the sides. Hair appressed laterally, sub-erect medianly, erect on the fourth segment.

♀. Differs only sexually.

*Type*, ♂, allotype, ♀, and ♂2♀♀ paratypes, Kampala, Uganda, 21.ix., and 2♂♂, 30.ix.1921 (*H. Hargreaves*), ex *Asura atricraspeda* (Lep. Arctiid.).

This species is extremely like *vara*, Curran, in the female sex and is difficult to separate, but there are fewer frontal bristles, and it is somewhat smaller.



**Zenillia sordida**, Villeneuve.*Zenillia sordida*, Villen., Ann. S. Afr. Mus., xv, p. 485, 1915.

♂, New Hanover, Natal, 1.ix.1923 (C. B. Hardenberg).

**Zenillia tenor**, Curran.

Originally described from the Belgian Congo.

**Zenillia illita**, Villeneuve.*Zenillia illita*, Villen., Ann. S. Afr. Mus., xv, p. 486, 1915.

♀, Elliott, South Africa, 12.v.1924 (H. K. Munro).

**Zenillia poultoni**, Villeneuve.*Exorista poultoni*, Villeneuve, Trans. Ent. Soc. London, p. 518, 1921.

Shining black, the head, pleura and mesonotum in front greyish pollinose; sternopleurals, 2-1-1 or 2-2. Length, 7 to 7.5 mm.

♂. *Head* grey pollinose; front about half as wide as either eye, the reddish brown vitta decidedly narrower than parafrontal; eight or nine pairs of frontals, three below the base of the antennae, the upper two reclinate; ocellars long; frontal hair rather fine, fairly abundant; outer verticals absent; no occipital setae behind the cilia; pile cinereous. Cheeks one-fourth as wide as eye-height; parafacials below half as wide as third antennal segment, wider than segment above. Vibrissae slightly above the prominent oral margin, the low ridges with bristly hairs on the lowest fifth. Palpi brown. Antennae black, the third segment moderately narrow, four times as long as the second; arista thickened on basal half, pubescent. *Thorax* with the mesonotum pollinose on the anterior fifth in the middle; dorso-centrals, 3-4; sternopleurals, 4; 4 pairs of marginal scutellars, the apical cruciate pair strong, horizontal. Free border of the scutellum broadly dark reddish. *Legs* black; pulvilli long; middle tibiae with a single antero-dorsal bristle; posterior tibiae closely ciliate. *Wings* cinereous hyaline; third vein with two bristles basally. Squamae white; halteres reddish. *Abdomen* with the broad sides usually obscure dark reddish except basally and on the fourth segment. First and second segments each with a pair of rather short, stout marginals, the third and fourth with a row of long ones, the fourth with two rows of discals. Hair abundant, mostly erect and coarse.

♂, Embu, Kenya Colony, 24.iii.1914 (J. St. Orde Browne); ♂, Durban, Natal, 17.x.1916 (H. Bell-Marley), ex *Iolaus silas* (Lep. Lycaen.); ♂, New Hanover, Natal, 28.viii.1913.

The type was reared from "Pterocarpus Lycaenid" near Ibadan, Nigeria.

**Zenillia lycaena**, sp. n.

Shining black, head and thorax cinereous pollinose, the mesonotum thinly so behind the suture; male with one orbital. Length, 5.25 mm.

♂. *Head*: front with strong yellowish tinge, five-eighths as wide as either eye, the reddish brown vitta two-thirds as wide as either parafrontal; seven pairs of frontals, two of them situated below the base of the antennae, the upper two reclinate; ocellars strong; outer verticals absent; no occipital setae behind the cilia. Pile cinereous; cheeks half as wide as eye-height. Parafacials very narrow below, widened above; oral vibrissae level with oral margin, the ridges with four or five bristles on the lowest fifth. Palpi brown. Antennae black; third segment wide, about five times as long as the second; arista thickened on the basal half, the penultimate segment about four times as long as wide. *Thorax*: mesonotum thinly pollinose behind the suture,



where, from posterior view, it is shining, the vittae obsolete or indistinct. Dorso-centrals, 3-4; sternopleurals, 2-1-1; four pairs of marginal scutellars, the apical pair cruciate. Scutellum brownish apically. *Legs* black; pulvilli small; middle tibiae with a single antero-dorsal bristle; posterior tibiae sub-ciliate. *Wings* cinereous hyaline, the veins mostly pale yellow, the third vein with two or three basal setae. Squamae pale yellowish, white basally. Halteres reddish with brown knob. *Abdomen* shining black; first segment with a pair of weak, the second with stronger marginals; third and fourth segments each with a row of marginals; the fourth with a row of much shorter discals and erect hair, the hair elsewhere appressed.

*Type*, ♂, Bloemfontein, South Africa, 13.ii.1923 (*H. E. Irving*), ex *Lycaena macalenga* (Lep.), in H. K. Munro's collection.

### **Zenillia versicolor**, sp. n.

Black; head and thorax with ochreous pollen; abdomen wholly shining black in ♂, with ochreous pollinose fasciae in ♀; four sternopleurals; penultimate arisal segment three times as long as wide. Length, 7 mm.

♂. *Head* with ochreous or dull golden-yellow pollen, which is paler on the face and lower part of the occiput. Front seven-tenths as wide as either eye, the dark brown frontal vitta a little more than half as wide as either parafrontal; two pairs of strong orbitals; about eight pairs of frontals, the lower two or three below the base of the antennae, the upper two very strong and reclinate; ocellars long; outer verticals well developed; a row of black setae behind the occipital cilia. Cheeks one-sixth as wide as eye-height. Parafrontals above as wide as third antennal segment, one-fourth as wide below. Vibrissae situated slightly above the oral margin, a few bristly hairs above them. Palpi blackish, the apex obscurely reddish. Antennae black, reaching almost to the vibrissae, the third segment four times as long as the second, rather wide; arista thickened on basal half. *Thorax*: mesonotum ochreous pollinose, the vittae distinct, the pleural pollen becoming grey below. Dorso-centrals, 3-4; sternopleurals, 4; four pairs of marginal scutellars, the apical pair cruciate, horizontal. Apex of scutellum broadly reddish. *Legs* black; pulvilli luteous, elongate; middle tibiae with a single antero-dorsal bristle; posterior tibiae rather sparsely ciliate. *Wings* cinereous hyaline, the veins yellowish basally; third vein with two or three setulae basally. Squamae yellowish; halteres blackish. *Abdomen* wholly shining black, with dense, short, appressed coarse hair above except laterally, the hair on the fourth segment more bristly and less appressed. First segment with small, second with pair of large marginals, the third and fourth segments each with a row of strong ones.

♀. Pulvilli small; immediate base of second abdominal segment, interrupted in the middle and obsolete laterally, basal fourth of the third segment, narrowly interrupted in the middle and a transverse, narrow basal triangle on either side of the fourth segment, pale ochreous pollinose. Hair coarser, longer and less abundant than in ♂; fourth segment with scattered discals.

*Holotype*, ♂, allotype, ♀, East London, Cape Province, South Africa, 22.v.1923. Paratypes: ♀, same data; ♂, 28.v, ♀, 18.v.1923 (*H. K. Munro*). Type in Munro's collection, paratype in British Museum.

### **Zenillia distans**, Villeneuve.

*Prozenillia distans*, Villeneuve, Ann. S. Afr. Mus., xv, p. 488, 1915.

♂, Zoerad, Sudan, 17.ii.1915 (*H. H. King*); ♀, Ibadan, S. Nigeria, 2.xii.1913 (*Dr. W. A. Lamborn*).

**Zenillia subdistincta**, Villeneuve.

*Catagonia subdistincta*, Villeneuve, Ann. S. Afr. Mus., xv, p. 484, 1915.

I have not recognised this species in the material at hand.

**Zenillia oculata**, Villeneuve.

*Exorista oculata*, Villeneuve, Wien. Ent. Ztg., xxix, p. 251, 1910.

Originally described from the Belgian Congo. It was not represented in the very large collection of Congo TACHINIDAE recently examined.

*Unrecognised Species.*

*Lydella boscii*, Macquart, Dipt. Exot. ii (3), p. 60, 1843. (*Exorista* according to Bezzi, but very doubtfully a *Zenillia* in the broad sense.) (Isle de France.)

*Exorista africana*, Jaennecke, Neue Exot. Dipt., p. 76, 1867 (*Phryno*, Bezzi) (Abyssinia).

*Exorista bigoti*, Jaennecke, l.c. (*Zenillia*? *Viviania*?) (Abyssinia).

*Exorista perlucida*, Karsch, Entom. Nachr., xii, p. 389, 1886 (Cape).

*Exorista echinaspis*, Bezzi, Boll. Soc. Ent. Firenze, xxxix, p. 53, 1908 (Eritrea).

*Carcelia hectica*, Speiser, Sjöstedt's Kilimandjaro-Meru Exped., x, p. 141, 1910.

*Exorista nemorilloides*, Bezzi, Parasitology, xv, p. 101, 1923 (Seychelles).

*Myxexorista habilis*, Br. & Berg., Denkschr. Akad. Wien, lviii, p. 332, 1891 (Cape).

**Sturmia laxa**, sp. n.

Black; face white; front more or less strongly ochreous; no setae behind the occipital cilia; sternopleurals, 2-1-1; a single antero-dorsal bristle on the middle tibiae. Length, 5.5 to 10 mm.

♂. *Head* white pollinose, the front mostly rather ochreous; frontal vitta reddish brown or blackish, narrower than either parafrontal; front almost or quite three-fourths as wide as either eye; frontals fairly strong, a secondary weak row, the two upper pairs strong and reclinate; ocellars short and weak, situated on either side of the anterior ocellus. Pile whitish. Cheeks with rather sparse, fine black hair, their width one-fifth the eye-height. Parafacials scarcely narrowed below, with scattered short hairs on the upper fourth, not as wide as the third antennal segment. Vibrissae situated almost half the length of the second antennal segment above the oral margin. Palpi reddish, darkened basally. Antennae black, the second segment often largely reddish, the third about twice as long as the second; arista thickened on a little more than the basal third. *Thorax* grey pollinose, with more or less luteous tinge, the vittae rather slender and usually not conspicuous. Acrostichals, 3-3; dorso-centrals, 3-4; 5 pairs of marginal scutellars, the weaker apical cruciate pair oblique. Scutellum reddish in ground-colour, with darker base. *Legs* black; pulvilli large. *Wings* cinereous hyaline. Squamae whitish. Halteres yellow. *Abdomen* often broadly reddish laterally on the second and third segments except apically, the basal three-fourths of the apical three segments in some lights yellowish grey or greyish yellow pollinose. First and second segments each with a pair of small marginals, the third and fourth each with a row, the latter with several discals and strong, erect hairs, the hair elsewhere shorter, sparse, appressed. Sexual patch roundish or sub-cordate, always somewhat pointed behind, not large.

♀. Front about as wide as either eye, the parafrontals each about twice as wide as the frontal vitta; two pairs of orbitals; outer verticals two-thirds as long as verticals. Pollen with stronger ochreous tinge, denser, the scutellum almost all reddish yellow in ground colour.

*Type*, ♂, allotype, ♀, Morogoro, Tanganyika, vii.1923 (*A. H. Ritchie*), from *Heliothis obsoleta*, F. (Lep. Noct.), in the British Museum. Paratypes: 2♂♂, 2♀♀, same data as types; ♀, Kimanuba, Tanganyika, from caterpillars on maize leaves; ♀, Tanganyika, i.1926 (*A. H. Ritchie*), from *Laphygma exempta*, Walk. (Lep. Noct.); 2♀♀, Entebbe, Uganda, 8.vii.1914 (*C. C. Gowdey*); 2♂♂, Barberton, S. Africa, 2.v.1913, 13.vi.1914 (*H. K. Munro*); ♀, Bloemfontein, 29.v.1920 (*H. E. Irving*); 3♂♂, Durban, Natal, 25.iii.1923; 4♀♀, Swaziland, i.1921; 4♂♂, 5♀♀, Rustenburg, Transvaal, 16.iv. and 15.xii.1925 (*A. J. Smith*); 6♂♂, 5♀♀, Westminster, Orange Free State, xii. 1925; ♂, Paardeberg, O.F.S., 31.v.1917 (*J. C. Faure*); ♂, New Hanover, Natal, 13.i.1914; ♀, Pretoria, Transvaal, 11.x.1918; ♀, Hope Town, Cape Province, 14.v.1917.

### ***Sturmia zonata*, sp. n.**

Sternopleurals, 2-1-1; one antero-dorsal bristle on middle tibiae; no black setae behind the occipital cilia; ocellars very small; front of male one-half, of the female three-fourths, as wide as either eye; arista thickened on basal half. Length, 5.5 to 10 mm.

♂. *Head* greyish pollinose, the face white, the front with yellowish tinge above; a few bristles outside the rather strong frontals, the hair short and fine; upper two frontals reclinate. Occipital pile whitish. Cheeks with fine, short black hair, one-sixth as wide as eye-height. Parafacials slightly narrowed below, with some hairs on the upper third, not as wide as the third antennal segment. Vibrissae situated a little above the oral margin; palpi reddish, with brownish base. Antennae black, the incisures more or less reddish; third antennal segment two and one-half times as long as the second. *Thorax* greyish pollinose, with slight luteous tinge above, the vittae conspicuous. Dorso-centrals, 3-4; 5 pairs of marginal scutellars, the small apical pair strongly cruciate and upturned. Scutellum mostly reddish in ground-colour. *Legs* black; pulvilli large. *Wings* cinereous hyaline. Squamae whitish. Halteres yellow. *Abdomen* with the sides of the intermediate segments more or less broadly reddish on the basal half, the basal third of the apical three segments densely greyish pollinose, narrowed towards the middle on the second segment and with an obscure slender black vitta interrupting each pollinose fascia. First and second segments each with a pair of very small marginals, the third and fourth each with a row, the fourth with erect hair and some discals on the apical half, the hair on the basal segments appressed. Sexual patch sub-cordate, transverse basally, narrowed apically, about as wide as long, the hairs composing it rather long.

♀. Front three-fourths as wide as either eye; two pairs of orbitals; third antennal segment twice as long as the second; outer verticals two-thirds as long as verticals.

*Type* ♂, allotype ♀, Entebbe, Uganda, 4.iv.1914 (*C. C. Gowdey*), in the British Museum. Paratypes: 2♂♂, Entebbe, 4.vi., 8.vii.1914, ♀, Kampala, Uganda, 10.viii.1916 (*C. C. Gowdey*); 3♂♂, Kampala, 20.vi.1924 (*H. Hargreaves*); 3♀♀, Nyasaland, ii.1916 (*C. Mason*); ♀, Zomba, Nyasaland (*H. S. Stannus*).

### ***Phorinia atypica*, sp. n.**

Superficially like *P. verritus*, Walker, but smaller and darker; ocellar bristles absent; intermediate abdominal segments without discal bristles; dorsocentrals, 3-4. Length, 6 to 7.5 mm.

♂. *Head* dark silvery-grey pollinose, the front golden brown; frontal vitta blackish, one-sixth the width of front; seven pairs of frontals, the upper three reclinate, the lower three below the base of the antennae; frontal hair conspicuous, black; ocellar hair abundant; outer verticals half as long as the verticals; no setae behind the occipital cilia; occipital pile cinerous; cheeks black-haired, one-fifth



the eye-height in width. Palpi black. Six or seven strong bristles on the facial ridges. Antennae black, reaching to the oral margin, the third segment four times as long as the second; arista brown, the penultimate segment four times as long as broad. Eyes with short whitish pile. *Thorax*: mesonotum and scutellum with golden brown or cinnamon brown pollen, the black vittae conspicuous. In life the metallic green ground shows through very strongly, but in dried specimens there is no trace of this unless they have been moistened; scutellum blackish basally. Pleura greyish pollinose, becoming golden brown above. Acrostichals, 3-3; dorso-centrals, 3-4; sternopleurals, 2-1; 4 pairs of marginal scutellars, the subapicals strongest, the apicals weakest, suberect, cruciate. Hair of the thorax black, not abundant, coarse on the scutellum. *Legs* black; coxae and the femora below, grey pollinose; pulvilli about as long as the last tarsal segment; middle tibiae with a single strong antero-dorsal bristle. *Wings* greyish hyaline, somewhat darkened in front. Squamae whitish. Halteres yellowish. *Abdomen* shining black; second and third segments with the basal third or less, the fourth with the basal fourth, whitish pollinose. First and second segments each with a pair of marginals, the third and fourth each with a row of very long ones, the apical half of the third and whole of the fourth segment with coarse bristly hairs.

♀. Agrees with the male, but the front is three-fourths as wide as either eye, convex, the upper reclinate frontal is short, and there are two strong proclinate orbitals.

*Type*, ♂, Durban, Natal, 7.v.1914 (*E. C. Chubb*), in the British Museum; allotype, ♀, East London, Cape Province, 29.v.1923, in Mr. Munro's collection; paratypes, 2 ♀♀, East London, 3.vi.1923 (*H. K. Munro*).

### **Campylochaeta, Rondani.**

There are three species belonging to this genus before me. All are metallic green or violaceous and resemble the species of *Gymnochaeta*, differing in having the facial ridges bristly as in *Phorocera*. They may be distinguished as follows:—

- |   |     |     |     |                            |
|---|-----|-----|-----|----------------------------|
| 1. Dorso-centrals 3-4; green, with violaceous reflections                                       | ... | ... | ... | 2                          |
| Dorso-centrals 3-3; violaceous, the abdomen partly green; legs black, the tibiae partly reddish | ... | ... | ... | <i>violacea</i> , sp. n.   |
| 2. Femora and tibiae reddish or reddish yellow; squamae white; pulvilli of ♂ elongate           | ... | ... | ... | <i>pallidipes</i> , sp. n. |
| Femora blackish, pale pollinose; upper lobe of squamae yellowish; pulvilli of ♂ short           | ... | ... | ... | <i>metallica</i> , Bezzi.  |

### **Campylochaeta violacea, sp. n.**

Violaceous, the abdomen partly green; white or ashy pollinose; tibiae reddish. Length, 8.5 to 9 mm.

♂. *Head* whitish pollinose, the face and occiput silvery, the parafrontals violaceous but appearing pollinose in some views; the dark brown frontal vitta is broad and appears whitish in most views; front above a little wider than either eye, somewhat widened anteriorly; ocellar bristles long and strong, the outer vertical bristles more than half as long as the verticals; upper two pairs of frontals reclinate. Occiput bluish violaceous in ground-colour, with two rows of black setae behind the cilia, the pile whitish. Checks hardly one-third as wide as eye-height, the hairs sparse. Face strongly receding, the bare parafacials only a little narrowed below; facial ridges with strong bristles except on the upper fifth, the vibrissae situated slightly above the oral margin. Palpi black. Antennae black, reaching almost to the vibrissae, the third segment broader than either parafacial, seven times as long as the short second; arista black, thickened on the basal three-fifths. *Thorax* with the disc of the mesonotum not thickly pollinose, the vittae distinct in some views; pleura



and scutellum thinly cinereous pollinose. Acrostichals, 3-3; dorso-centrals, 3-3; intra-alars, 3; sternopleurals, 3; scutellum with four pairs of marginals, the apical pair weakest, slightly cruciate and weakly upturned. Hair of thorax wholly black. *Wings* conspicuously darkened, the veins blackish; bend of the fourth vein angular, the posterior cross-vein curved outwards, joining the penultimate section of the fourth vein near its apical fourth; third vein with about six strong bristles basally. Squamae white, with yellowish rim. Halteres brownish yellow. *Abdomen* with the very broad apices of the segments greenish, the fourth segment mostly so, the cinereous pollen tessellate, appearing silvery in some views. First and second segments each with a pair of long, strong marginals, the second and third each with a pair of strong discals and some short, stout ones; third with a row of strong marginals, the fourth with three rows of bristles on the apical three-fifths, the basal row strongest. Abdominal hair coarse, mostly sub-appressed, black.

♀. Front one-fifth wider than eye, with two pairs of orbital bristles; third antennal segment narrower, hardly as wide as either parafacial and hardly six times as long as the second segment; arista thickened to a little beyond the middle.

*Type* ♂, allotype ♀, Kabete, Kenya 30.xii.1918, and one ♂ paratype, Kabete, 31.x.1918 (T. J. Anderson).

### ***Campylochaeta pallidipes*, sp. n.**

Metallic green, the sides and venter thickly cinereous pollinose, the dorsum of the abdomen thinly so, the pollen not tessellate; face, palpi, legs and halteres, reddish yellow, the tarsi black. Length, 7 mm.

♂. *Head* creamy white pollinose, the occiput only thinly so above; parafrontals without pollen, except for a thin coating evident only from posterior view. Front one-sixth wider than either eye, somewhat broadened anteriorly, the sides gently concave; frontal vitta brown, at its middle decidedly narrower than either parafrontal; ocellar bristles long; outer verticals long but slender. Only a single row of black setae behind the occipital cilia, the occipital pile white. Cheeks five-twelfths as wide as eye-height, green in ground-colour, densely pollinose, the hair fine, black. Parafacials yellow, but little narrowed below; facial ridges with strong bristles except on the upper fifth; vibrissae situated slightly above the oral margin. Face strongly retreating. Palpi yellowish. Antennae black, reaching almost to the vibrissae, the third segment hardly as wide as either parafacial, almost six times as long as the second; arista thickened to beyond the middle. Eyes with whitish pile. *Thorax* with the pollen of the mesonotum and scutellum only evident from the posterior view, the sides of the former and the remainder of the thorax rather thickly cinereous, pollinose. Acrostichals, 3-3; dorso-centrals, 3-4; intra-alars, 3; sternopleurals, 3; scutellum with four pairs of marginals, the apical pair weakest, cruciate, moderately upturned. Sternopleura with some fine, pale hair. *Legs* reddish yellow, the coxae and tarsi blackish, the former pollinose; pulvilli almost as long as the fifth tarsal segment, luteous. *Wings* cinereous hyaline; third vein with three or four bristles basally; venation as in *C. violacea*. Squamae whitish. *Abdomen* bright green above, the apices of the segments somewhat darker, the fourth segment more brassy and more conspicuously pollinose. First and second abdominal segments each with a pair of strong marginals, the second and third each with a pair of discals, the latter with a row of marginals, the fourth with three irregular rows of strong bristles and some weaker ones. Abdomen on the basal half of the lower surface with fine white hair towards the middle.

♀. Front equal in width to either eye; two pairs of orbital bristles. Coxae mostly reddish; no pale hair on the pleura and less on the lower surface of the abdomen.

*Type* ♂, allotype ♀, Kabete, Kenya, 1.x.1918 (T. J. Anderson).

Host: *Plusia orichalcea* (Lep. Noct.).

In this species the bristles are finer than in *C. violacea* and the long pulvilli separate the ♂ from both that species and *metallica*.

**Campylochaeta metallica**, Bezzi.

*Campylochaeta metallica*, Bezzi, Bull. Soc. Ent. Ital., xxxix., p. 57, 1907.

Seven specimens from Kenya: N. of Mt. Kenya, 8,300 ft., 18.ii.1911, and E. side of the edge of forest on the Aberdare Mts., 7,300 ft., 24.ii.1911 (T. J. Anderson).

Originally described from the male sex from Eritrea. The ♂ has either one or two pairs of orbital bristles, the upper one often being very small or absent. Some of the specimens show scarcely any violaceous tinge, but the character is variable in allied genera. Bezzi's statement that the occiput is green enables me to separate this species from the preceding two and identify it with moderate certainty. The frontal vitta varies in colour from rusty brown to almost black, and is whitish pollinose from most views.

**Gonia munroi**, sp. n.

Related to *G. sicula*, Desvoidy (*fasciata*, Meigen), but the bristles on the face are decidedly shorter than the apical arisal segment, which is only about one and one-half times as long as the second, the arista rather slender, the head much flatter, as in the species placed in *Cnephalia*. The marginals on the first abdominal segment as in *Cnephalia bucephala*, Meigen, but the abdomen is much more extensively pollinose, the head silvery white or silvery. In this species the antennae of the male are quite typical of *Gonia*, while in the female they are typical of *Cnephalia*. The head is very short, the parafacials above being very much narrower than the eye in profile. *Gonia fasciata*, Wiedemann, is a larger species with long head and very different appearance and has the humeri yellowish. Length, 9 to 10 mm.

♂. Head blackish in ground-colour, the face, cheeks, frontal vitta and vertical area, yellowish, the whole densely silvery-white pollinose, the vertex somewhat yellowish-tinged. Front one-seventh wider than either eye, widening below; parafrontals with three more or less regular rows of bristles and some additional bristly hairs. Outer verticals strong; a single row of black occipital cilia; occipital pile white; cheeks with black bristles; parafacials with three irregular rows of black bristles, the inner row unusually strong. Facial depression deep, the distance between the vibrissae greater than the width of parafacial below. Antennae reaching to the vibrissae or nearly so, the second segment not one and one-half times as long as wide, the third rather broad, but varying due to drying, its apex truncate, angular above, rounded below; second arisal segment not two-thirds as long as the third, the first short. Palpi reddish. Thorax cinereous pollinose, rather thinly so above, the vittae not conspicuous; scutellum yellowish, with the broad base black, with three pairs of strong marginals and a pair of suberect, small bristles between the apical pair. Legs black; pulvilli elongate. Wings cinereous hyaline, a little darkened or luteous along the anterior border except apically. Abdomen shining black, the basal half or more of the apical three segments cinereous pollinose in some views, the fourth more than half pollinose. First and second segments each with a pair of fairly robust marginals; fourth segment with a sub-basal row of short, stout bristles, subapical row of stout ones and terminal row of fine ones.

♀. Frontal bristles less conspicuous, the outer row replaced by two proclinate orbitals; second antennal segment half as long as the third; facial depression rather shallow; vittae of thorax more distinct.

The base of the third antennal segment and apex of the second is broadly reddish in both sexes.

Described from 5♂♂, 8♀♀, from Tanganyika and South Africa. The type male and female are from Tanganyika (A. H. Ritchie), reared from larvae of *Laphygma*

*exempta*, Walker (Lep. Noct.). The remaining specimens are from the collection of the Division of Entomology, Pretoria, and were submitted by Mr. H. K. Munro and Dr. Guy A. K. Marshall.

### **Macroprosopa, Br. & Berg.**

I have an undescribed species from Cape Province, S. Africa, which differs from *M. atrata*, Fallén, as follows:

Palpi wholly reddish yellow; cinereous pollinose species ...	<i>rufipalpis</i> , sp. n.
Palpi mostly black or brown; shining blackish species ...	<i>atrata</i> , Fallén.

### **Macroprosopa rufipalpis, sp. n.**

Black, greyish pollinose, palpi and tips of the femora reddish yellow.

♂. *Head* with the cheeks as wide as half the eye-height, the oral margin strongly oblique, almost perpendicular in front; vibrissae situated a little below the lower level of the eyes, one or two bristles above them. Face short; parafacials broad, prominent above, bearing coarse hair; cheeks with coarse black hair. Front narrowest at the upper fourth, where the parafrontals are linear, the frontal vitta black. Frontal bristles extending as far as the apex of the second antennal segment, half of them below the base of the antennae, in a double row: the bristles stop a little above the middle of the front; ocellar bristles strong, the verticals very weak. Hair of the head black, a little pale hair near the neck. Eyes thickly clothed with long pale pile. Palpi reddish yellow. Antennae more or less reddish on the second segment apically, the third segment not longer than the second, one and one-fourth longer than wide, its apex obtusely rounded. Head pollinose except the frontal vitta. *Thorax* with the mesonotum somewhat darker than the pleura, with four obscure, rather narrow dark vittae. Acrostichals, 2-3; dorso-centrals, 3-3; posterior sublateral bristle very weak or absent; sternopleurals, 1-1-1, the second weak; 3 pairs of marginal scutellars, the apical pair weakly cruciate with a pair of apical hairs between them; a pair of very weak discals. *Legs* black; pulvilli long, yellowish. *Wings* cinereous hyaline; apical cell closed in margin of the wing a little before the apex (sometimes very narrowly open or very shortly petiolate); third vein with two or three basal bristles; apical cell narrow, the apical cross-vein nearly straight. The posterior cross-vein joining the penultimate section of the fourth vein at its apical third. Squamae whitish. Halteres yellow. *Abdomen* with the linear segmental apices darker in some views, inclined to be weakly checkered. First segment without dorsal bristles, the second and third each with a pair of discals and marginals, and two or more pairs of lateral marginals; fourth segment with scattered long bristles. Hair long, sparse apically.

*Holotype* ♂ and 4♂ paratypes, Klipplaat, Cape Province, 20.ix. 1917.

### **Ocypteromima, Townsend.**

*Ocypteromima*, Townsend, Ann. Mag. Nat. Hist., xvii, p. 175, 1916.

*Pyrrhosiella*, Villeneuve, Ann. S. Afr. Mus., xv, p. 501, Dec. 1916.

### **Ocypteromima polita, Townsend.**

*Ocypteromima polita*, Townsend, Ann. Mag. Nat. Hist., xvii, p. 175, 1916.

*Pyrrhosiella cingulata*, Villeneuve, Ann. S. Afr. Mus., xv, p. 503, 1916.

I have not the slightest doubt about this synonymy being correct as specimens agree perfectly with both descriptions. Specimens before me are from the following localities:—

Kampala, Uganda, 10.ix.1918 (*C. C. Gowdey*); Eruku, N. Nigeria, 24.viii. 1912 (*Dr. J. W. Scott-Macfie*); Gold Coast (*A. E. Evans*); Dowa Dist., Nyasaland (*Dr. J. B. Davey*), and Fort Johnston 2.iv.1915 (*Dr. W. A. Lamborn*); Belgian Congo (*Lang & Chapin*); South Africa (*H. K. Munro*).



## THE GENERIC TYPES OF THE DIASPIDAE (HEMIPTERA).—PART II.\*

By L. EMERY MYERS,  
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W.

(PLATES XXVI.—XXIX.)

Since the appearance of the first paper in this proposed series our attention has been called by Mr. E. E. Green to the desirability of developing a terminology for the various structures of the Diaspid scales which shall be more satisfactory than that at present in general use. We are entirely in accord with his view that many of the terms at present employed are not suitable and that they need to be replaced by others of more precise application.

We have decided, however, not to make any attempt at the development of such a terminology at the present time, the controlling reason for this decision being found in the belief that the morphology of the Diaspid scales—not to speak of the other groups—is still too insufficiently understood to permit the formulation of a terminology which shall be at all enduring. It is our belief that any system now devised is too likely to require extensive later modification. This is certainly the case with one recent attempt thus to devise such a system, an attempt that fails of its purpose because of lack of knowledge. From this point of view it seems best to leave the question of such a terminology until such time as at least a large proportion of the Diaspid types have been examined in greater detail.

For the present we shall content ourselves with the use of common and, in general, well understood terms or with simple descriptive phrases. An exception will be made in the case of certain terms which it seems well should be eliminated as soon as possible. One such term is the expression "pygidial lobes" for the usually paired structures of the pygidial margin. For these Mr. Green suggests that the term "trulla," which has already been employed by some authors, is better. Another substitution suggested by Mr. Green is that of "perivulvar" to designate the cluster of pores about the genital opening, and this we shall utilise.

In this paper four genera, *Aulacaspis*, *Chionaspis*, *Lepidosaphes* and *Chrysomphalus*, will be treated by Mr. Myers.—G. F. Ferris.

3. Genus **Aulacaspis**, Cockerell.

The type of this genus is designated by the Fernald Catalogue as *Aspidiotus rosae*, Bouché—*Diaspis rosae* (Bouché).

**Aulacaspis rosae** (Bouché) (Plate xxvi).

SCALE. *Female* (Plate xxvi, fig. 4) averaging 1.8 mm. in diameter, circular or sub-circular, slightly convex, white and rather thin; exuviae lying toward one side, the first skin usually projecting slightly from the margin, the second skin covered with secretion, the first naked; ventral scale consisting of a mere film which remains attached to the host. *Male* (Plate xxvi, fig. 5) about 1.3 mm. long and 0.4 mm. wide, white and of a felted texture, with three distinct, longitudinal carinae.

*Exuviation* occurring by the rupture of the ventral derm between the antennae and the mouth-parts, the ventral skin being pushed back to the posterior end.

MORPHOLOGY OF THE FEMALE. *Adult female* (Plate xxvi, fig. 16) about 1.2 mm. long, elongate in form, the anterior region formed by the fusion of the head and pro- and mesothorax being swollen and distinctly wider than the metathorax

\* For Part I. see Bulletin of Entomological Research, xvi, pp. 163-167, pls. xii-xiii (1925).



and the abdominal segments; derm membranous throughout, except for the pygidium and a number of small chitinized areas on the cephalothoracic region and between the segments; abdomen quite strongly constricted between the segments.

Antennae (Plate xxvi, fig. 13) consisting merely of a small tubercle bearing two setae. Spiracles (Plate xxvi, fig. 14) all accompanied by a small stigmatic plate which encloses a small cluster of pores, the anterior spiracles with a slightly larger number of pores than the posterior.

Tubular ducts abundant, those of the pygidium (third to fifth abdominal segments) arranged in distinct rows on the dorsum (Plate xxvi, fig. 1). Ducts of the pygidial margin (Plate xxvi, figs. 3 and 8) but little larger than those of the dorsal series (Plate xxvi, fig. 7). Smaller ducts of this "two-barred" type occur along the lateral margins of the abdominal segments anterior to the pygidial area. On the ventral side of the body, from head to pygidium, and on the dorsal side of the cephalothoracic region are to be found a very few ducts which more closely approach the "one-barred" type (Plate xxvi, fig. 11). Membranous gland spines (Plate xxvi, fig. 10) occur along the margin of the pygidium and chitinized gland spines (Plate xxvi, fig. 9) occur along the lateral margins of the abdomen as indicated in fig. 16.

Ventral side of the abdomen with a series of structures, to which we are applying the term "conchiform plates," on the intersegmental lines between the second to sixth segments. These structures (Plate xxvi, fig. 12) consist of a group of small, slightly raised, smooth areas around which pass the dermal ridges.

The pygidium (Plate xxvi, fig. 1) is apparently composed of the third to eighth abdominal segments (assuming the ninth and subsequent segments to be obsolete). The segmentation is clearly indicated by the dorsal, intersegmental rows of ducts and by the marginal setae. Margin of the pygidium (Plate xxvi, fig. 3) with three pairs of trullae. The members of the median pair are fused at the base and form a distinct notch in the pygidial margin, their mesal margins divergent and slightly serrate. There are no gland spines, pores or setae in this notch. Second and third pairs of trullae bilobed.

Perivulvar pore groups five in number, the lateral groups nearly continuous. Anal opening distant from the posterior margin of the body.

*Second stage of female.* There are available of this stage only exuviae. The pygidial margin (Plate xxvi, fig. 15) has but five tubular ducts and the dorsum of the pygidium is without tubular ducts.

*First stage* (Plate xxvi, fig. 6), without large tubular ducts, the margins of the body with a series of very minute ducts, apparently one to each segment. Pygidial area (Plate xxvi, fig. 6, *a*) with two pairs of trullae present, these representing the second and third pairs of the adult. The second pair is distinctly divided into two lobes. The pygidial margin bears also two pairs of gland spines as indicated in fig. 6, *a*. Antennae (Plate xxvi, fig. 2) five-segmented, the fifth segment elongate and annulate.

### Genus *Chionaspis*, Signoret.

The type of this genus is accepted as being *Coccus salicis*, Linnaeus. This species appears to be widely spread in Europe, where it has been described under various names. For the purposes of this paper we are utilising material from *Sorbus* in Italy, distributed in the *Chermotheca Italica* as this species.

### *Chionaspis salicis* (Linnaeus) (Plate xxvii).

*SCALE. Female* (Plate xxvii, fig. 4) about 2 mm. long, elongate, broadening posteriorly, with exuviae at extreme anterior apex, white, but slightly convex; ventral scale merely a thin film which remains attached to the host. *Male* (Plate xxvii fig. 5) 1.5 mm. long, white, felted, distinctly tricarinate, exuviae at one end.

*Exuviation* occurring by the rupture of the ventral derm between the antennae and the mouth-parts, the ventral skin being pushed back toward the posterior end.

**MORPHOLOGY OF THE FEMALE.** *Adult female* (Plate xxvii, fig. 17) about 9 mm. long, elongate, broadening posteriorly, the cephalothoracic region not expanded laterally, but occupying about half the length of the body; derm membranous throughout except for the pygidial region; intersegmental constrictions pronounced, the lateral lobes of the abdominal segments quite prominent.

Antennae (Plate xxvii, fig. 11) consisting merely of a small tubercle which bears a pair of small setae. Spiracles borne upon an indistinct stigmatic plate, the anterior pair accompanied by as many as eight pores, the posterior pair with three or four.

Tubular ducts numerous, those of the pygidial area arranged in distinct rows, those of the pygidial margin (Plate xxvii, fig. 9) but little larger than those of the dorsum (Plate xxvii, fig. 10). Ducts of this "two-barred" type occur on the dorsum of the abdomen and at the lateral margins of the abdominal and thoracic segments, as indicated in fig. 17. Sparsely distributed on the ventral side of the body are extremely small, apparently "one-barred" ducts (Plate xxvii, fig. 13). The gland spines of the metathoracic and first and second abdominal segments and partially of the third abdominal segment are short and slightly chitinized (Plate xxvii, fig. 12), while those of the pygidial area are longer and membranous (Plate xxvii, fig. 8).

The distribution of the tubular ducts on the pygidium is as indicated in Plate xxvii, fig. 1.

Ventral side of the abdomen with a series of "conchiform plates" (Plate xxvii, fig. 15), these quite indistinct and somewhat variable in number. There may be as many as five pairs in the intersegmental furrow from the posterior margin of the metathorax to the posterior margin of the fourth abdominal segment or the first two pairs may be lacking.

Pygidium apparently composed of the fourth to eighth abdominal segments (assuming the ninth and any subsequent segments to be suppressed), the segmentation being clearly defined by the intersegmental rows of ducts and the marginal setae. Margin of the pygidium (Plate ii, fig. 3) with two distinct pairs of lobes, the third pair, although recognisable, being quite obscure. The members of the median pair are closely yoked together at the base, and their mesal margins are approximate for a portion of their length. There are no setae, gland spines or pores between the members of this pair. Second pair of lobes distinctly bilobed and with a pair of small paraphyses.

Perivulvar pores in five groups, the lateral groups almost confluent. Anal opening distant from the posterior border.

*Second stage of the female.* Exuviae only available. The pygidium differs from that of the adult in lacking all dorsal ducts (Plate ii, fig. 16) and in having the marginal ducts fewer.

*First stage* (Plate xxvii, fig. 6). Antennae (Plate xxvii, fig. 2) five-segmented, the terminal segment but little elongate and not at all annulate. Body apparently entirely without tubular ducts, or if present these must be extremely minute. Pygidial margin (Plate xxvii, fig. 7) with two pairs of lobes, these representing the second and third pairs of the adult, the mesal pair divided into two unequal lobes.

##### 5. Genus *Lepidosaphes*, Shimer.

The type of this genus is accepted as being the *Coccus conchiformis* of Gmelin, which is considered to be a synonym of *Coccus ulmi*, Linnaeus. For the purposes of this paper we are employing specimens taken from *Salix* in California and agreeing with what is commonly accepted as *Lepidosaphes ulmi*. There is some question

concerning the possibility that two species are confused under this name, but this will have no bearing on the matter of generic characters, the two species—if indeed there be two—differing only in minor details. Owing to the extreme rarity, if not even non-existence, of males in *L. ulmi*, the figure of the male scale which we are presenting has been based upon specimens of the very closely related and certainly congeneric *L. beckii* (Newm.).

**Lepidosaphes ulmi** (Linnaeus) (Plate xxviii).

SCALE. *Female* (Plate xxviii, fig. 11) elongate, about 3.5 mm. long and 1 mm. wide, brown or grey in colour, slightly convex; exuviae at the extreme apex, covered with a film of wax; ventral scale thick, attached at the margins to the dorsal scale, complete except for a triangular opening at the posterior end. *Male* (Plate xxviii, fig. 12) similar in form, texture and colour to that of the female and about 1.8 mm. long and 0.5 mm. wide; ventral scale white, thick, except in the centre, and attached at the sides to the dorsal scale.

*Exuviation* occurring by the rupture of the ventral derm between the antennae and the mouth-parts, the ventral skin being pushed back to the posterior end.

MORPHOLOGY OF THE FEMALE. *Adult female* (Plate xxviii, fig. 15) about 1.5 mm. long, elongate, slightly cuneiform or the sides nearly parallel; cephalothoracic region composing at least half the length of the body; intersegmental constrictions pronounced, the abdominal segments being produced into quite prominent lateral lobes; derm membranous throughout except for the pygidial area.

Antennae (Plate xxviii, fig. 7) consisting of a small, irregular tubercle which bears a pair of small setae. Spiracles simple, without a stigmatic plate, the anterior pair accompanied by a group of five or six pores, the posterior pair without pores.

Tubular ducts abundant, of the "two-barred" type, except for those which open through the gland spines, tending to be arranged in quite definite rows in the pygidial area. Marginal ducts of the pygidium (Plate xxviii, fig. 9) much larger than those of the dorsum or of the marginal areas anterior to the pygidium (Plate xxviii fig. 10). The arrangement of the tubular ducts at the margins of the segments and on both dorsal and ventral sides of the abdomen is as indicated in fig. 15. Gland spines of the third and fourth abdominal segments and the pygidial area membranous (Plate xxviii, fig. 4) while on the first and second abdominal segments there are marginal groups of stout, chitinized gland spines (Plate xxviii, fig. 3) on the ventral side.

Third and fourth abdominal segments commonly with a chitinized spur (Plate xxviii, fig. 14) on the ventral side near the margin. The occurrence of this is slightly variable, and it may at times be lacking on one of the segments.

Pygidium (Plate xxviii, fig. 1) composed of the fifth to eighth segments (assuming the ninth and subsequent segments to be suppressed), the segmentation clearly indicated by the intersegmental rows of ducts and the marginal setae. Margin of the pygidium (Plate xxviii, fig. 8) showing but two distinct pairs of trullae. Median trullae quite widely separated from each other, the interspace with two gland spines. Second pair of trullae shallowly bi-lobed. Orifices of the marginal tubular ducts enclosed within a heavy chitinous ring.

Perivaginal pores in five small groups. Anal opening remote from the posterior border.

*Second stage of the female.* There are available only exuviae. In these the pygidial margin differs from the adult in the reduced number of ducts (Plate xxviii, fig. 13). The dorsal ducts are entirely lacking except for the very few indicated in the figure.



*First stage* (Plate xxviii, fig. 5). Antennae (Plate xxviii, fig. 2) six-segmented, the terminal segment somewhat elongate but not at all annulate. Tubular ducts extremely small, the margin of the body with nine pairs, eight of which are on the abdomen and open through gland spines, the other pair being on the mesothorax. Pygidium with three pairs of trullae (Plate xxviii, fig. 6), the second pair divided into two parts.

*Notes.* This species is so closely similar to *L. beckii* (Newm.) that the two may easily be confused. The principal difference between the two is to be found in the fact that in *L. ulmi* the metathorax bears on the ventral side a considerable number of small tubular ducts, while in *L. beckii* this same area bears a number of small, chitinized gland spines. Also in *L. beckii* the median pair of trullae are twice notched on the mesal margin, while in *L. ulmi* there is but one notch, and in *L. beckii* the lateral lobes of the abdominal segments are much more produced than in *L. ulmi*.

#### 6. Genus *Chrysomphalus*, Ashmead.

The type of this genus is *Chrysomphalus ficus*, Ashmead, which is considered to be a synonym of *Coccus aonidium*, Linnaeus. The drawings accompanying this paper are based upon specimens from *Aspidistra* in the green-house at Stanford University, these agreeing closely with other material from various other sources, all representing what is commonly accepted as this species.

#### *Chrysomphalus aonidium* (Linnaeus) (Plate xxix).

*SCALE.* *Female* (Plate xxix, fig. 4) circular, 1.8 mm. in diameter, slightly convex, chocolate-coloured; exuviae central, covered with a film of wax; ventral scale consisting merely of a powdery white film which remains attached to the host. *Male* (Plate xxix, fig. 12) oval, length 1.21 mm., width 0.7 mm., texture and colour as in female; exuviae central or sub-ventral; ventral scale a mere powdery film.

*Exuviation* occurring by the rupture of the ventral derm between the antennae and the mouth-parts, the ventral skin being pushed toward the posterior end of the body.

*MORPHOLOGY OF THE FEMALE.* *Adult female* (Plate xxix, fig. 15) about 1.1 mm. long; form turbinate or deltoid; derm membranous throughout except for the pygidium; intersegmental constrictions slight, the lateral lobes of the abdomen not protruding, about half of the length of the body being formed by the cephalothoracic region.

Antennae (Plate xxix, fig. 16) consisting merely of a minute tubercle which bears a single seta. Spiracles simple, without a stigmatic plate and without accompanying pores.

Tubular ducts all of the "one-barred" type, which has previously been described for *Aspidiotus hederae*, but varying greatly in length (Plate xxix, figs. 8-11, 13), those of the dorsal aspect of the pygidium being very long and slender. The distribution of the tubular ducts on the body is as indicated in fig. 15, there being a very few, short ducts along the margin of the cephalothoracic region and the abdominal segments, the second abdominal segment having a small cluster on the dorso-lateral margin.

The dorsal tubular ducts of the pygidium are arranged in definite series (Plate xxix, fig. 1), these probably marking intersegmental lines. As these series of ducts approach the margin of the pygidium there is a tendency toward the formation of a depressed furrow, the margins of which are supported by chitinous, internal paraphyses. The ventral tubular ducts are short and very slender, few, arranged in a sub-marginal series.



Margin of the pygidium (Plate xxix, fig. 7) with three pairs of trullae of nearly equal size. Members of the median pair separated, the interspace with two small, fringed plates and a single duct orifice. Second interspace likewise with two fringed plates, third interspace with three and beyond the third pair of trullae a series of very deeply fringed plates. The paraphyses, which arise in part from the bases of the trullae, are arranged as indicated in fig. 7.

Perivaginal pores in four groups. Anal opening quite close to the apex of the pygidium.

*Second stage of female.* In general very similar to the adult, the pygidial margin being practically identical, the dorsum, however, with much fewer ducts.

*First stage* (Plate xxix, fig. 5). Antennae (Plate xxix, fig. 2) five-segmented, the terminal segment annulate and about as long as the others combined. Tubular ducts few, there being a series of four along the margin of the abdomen and a very few, extremely minute ducts on the dorsum of the cephalothoracic region. Margin of the pygidial area (Plate xxix, fig. 6) with two prominent trullae, these corresponding (on the basis of a comparison with other forms) to the second and third pairs of the adult. Associated with these are very minute fringed plates as indicated.

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EXPLANATION OF PLATE XXVI.

*Aulacaspis rosae* (Bouché).

- Fig. 1. Pygidium of adult ♀.  
" 2. Antenna of first stage.  
" 3. Pygidial margin of adult ♀.  
" 4. Scale of ♀.  
" 5. Scale of ♂.  
" 6. First stage.  
" 7, 8. Tubular ducts of dorsum of pygidium.  
" 9. Chitinized gland spine of abdominal margin.  
" 10. Membranous gland spine of pygidial margin.  
" 11. Tubular duct of venter of pygidium.  
" 12. Conchiform plates.  
" 13. Antenna of adult ♀.  
" 14. Posterior spiracle of adult ♀.  
" 15. Pygidium of second stage of ♀.  
" 16. Adult ♀.



*Aulacaspis rosae* (Bouché).



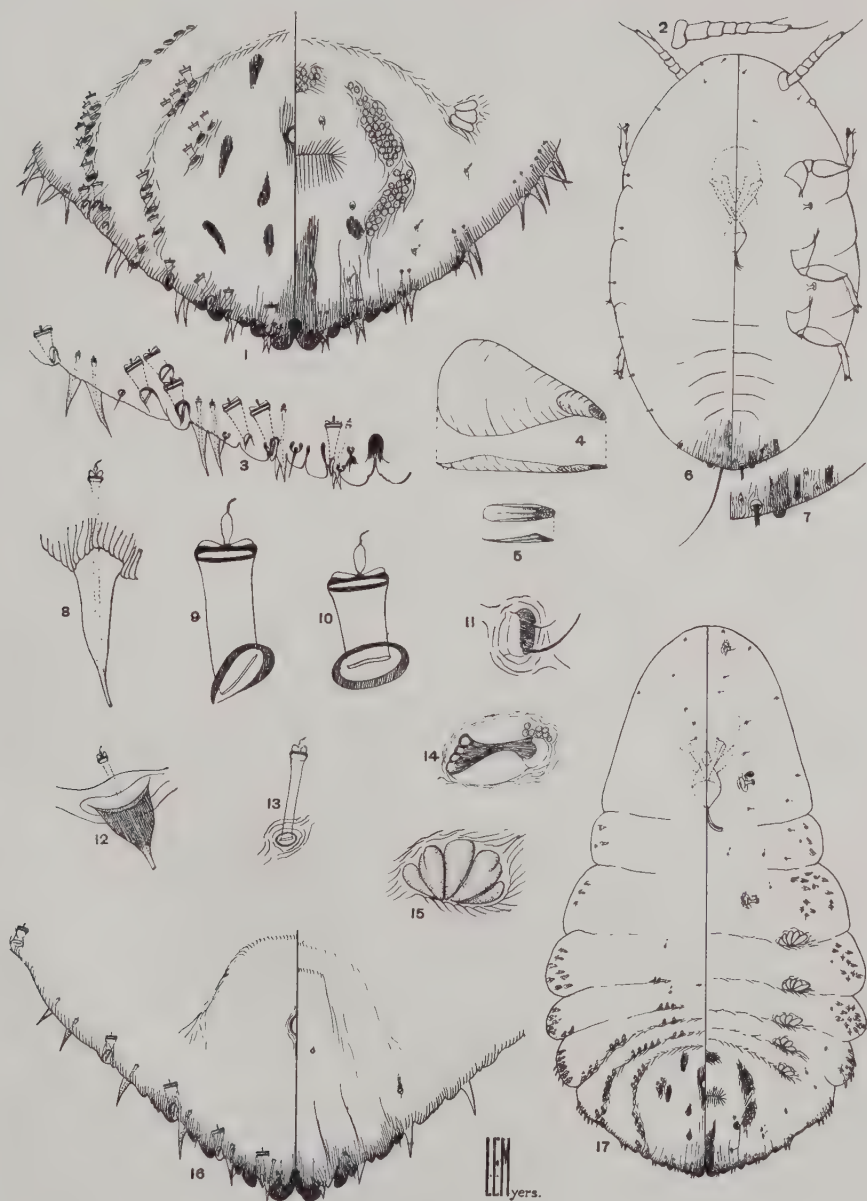




EXPLANATION OF PLATE XXVII.

*Chionaspis salicis* (Linnaeus).

- Fig. 1. Pygidium of adult ♀.  
,, 2. Antenna of first stage.  
,, 3. Pygidial margin of adult ♀.  
,, 4. Scale of ♀.  
,, 5. Scale of ♂.  
,, 6. First stage.  
,, 7. Pygidial margin of first stage.  
,, 8. Membranous gland spine of pygidial margin.  
,, 9, 10. Tubular ducts of dorsum.  
,, 11. Antenna of adult ♀.  
,, 12. Chitinized gland spine of abdominal margins.  
,, 13. Tubular duct of venter of pygidium.  
,, 14. Anterior spiracle of adult ♀.  
,, 15. Conchiform plate.  
,, 16. Pygidium of second stage of ♀.  
,, 17. Adult ♀.



*Chionaspis salicis* (Linnæus).



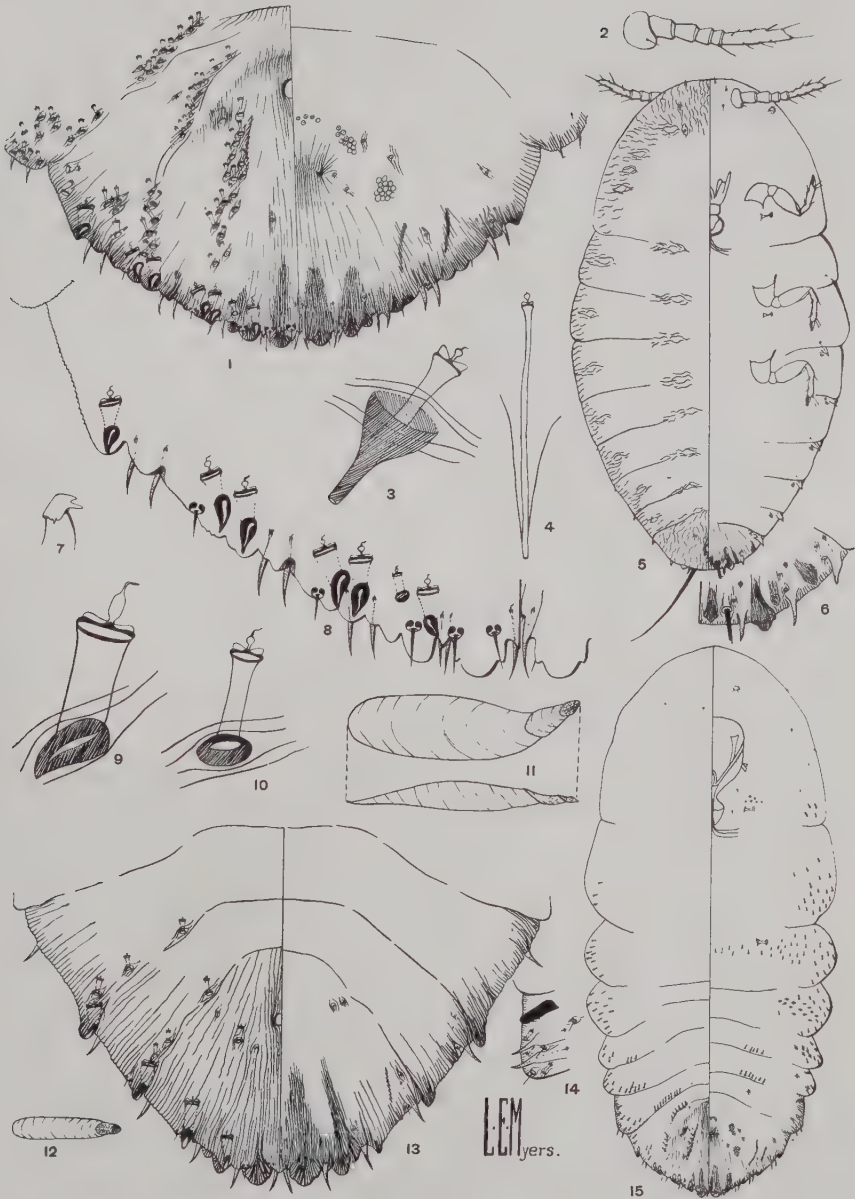




EXPLANATION OF PLATE XXVIII.

*Lepidosaphes ulmi* (Linnaeus).

- Fig. 1. Pygidium of adult ♀.  
" 2. Antenna of first stage.  
" 3. Chitinized gland spine of abdominal margin.  
" 4. Membranous gland spine of pygidial margin.  
" 5. First stage.  
" 6. Pygidial margin of first stage.  
" 7. Antenna of adult ♀.  
" 8. Pygidial margin of adult ♀.  
" 9. Tubular duct of pygidial margin.  
" 10. Tubular duct of dorsum of pygidium.  
" 11. Scale of adult ♀.  
" 12. Scale of ♂ (of *L. beckii*).  
" 13. Pygidium of second stage of ♀.  
" 14. Marginal spur of third or fourth abdominal segments.  
" 15. Adult ♀.



*Lepidosaphes ulmi* (Linnæus).







EXPLANATION OF PLATE XXIX.

*Chrysomphalus aonidum* (Linnaeus).

- Fig. 1. Pygidium of adult ♀.  
" 2. Antenna of first stage.  
" 3. Pore from perivaginal group.  
" 4. Scale of adult ♀.  
" 5. First stage.  
" 6. Pygidial margin of first stage.  
" 7. Pygidial margin of adult ♀.  
" 8, 9. Tubular ducts of dorsum of pygidium.  
" 10, 11. Tubular ducts of venter of pygidium and of abdominal margin.  
" 12. Scale of ♂.  
" 13. Inner end of tubular duct.  
" 14. Pygidium of second stage of ♀.  
" 15. Adult ♀.  
" 16. Antenna of adult ♀.



*Chrysomphalus aonidum* (Linnæus).





METHODS FOR COLLECTING PARASITES OF EARWIGS. *W.*

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(PLATE XXX.)

It is widely known that the biological method for the control of insect pests is receiving considerable attention from Economic Entomologists at the present day. One of the insects against which this method is being tried is the common earwig (*Forficula auricularia*), which is a very serious pest of orchards, etc., in such countries as New Zealand where it has been accidentally introduced from Europe.

Through co-operation between the Imperial Bureau of Entomology, Rothamsted Experimental Station, and the Cawthron Institute, Nelson, attempts have been made to control the earwig in New Zealand by the introduction of two Tachinid flies that are parasitic on it, *Digonochaeta setipennis*, Flin., and *Rhacodineura antiqua*, Meig. These flies are obligatory parasites, being entirely dependent on this particular host for the completion of their life-cycle, and they are lethal in effect. The larvae having emerged from their dead or moribund host, soon pupate, and it is in the pupal stadium that these insects can most conveniently be transmitted in cold storage. Mr. A. M. Altson, of the Imperial Bureau of Entomology, was in charge of this work in England in 1924 and 1925, but, unfortunately, owing to ill-health he was obliged to give it up. In the autumn of 1926, at the request of Dr. Tillyard, it was decided to forward a further batch of parasitic puparia to New Zealand. For this purpose large quantities of earwigs had to be captured in the field, and transferred to cages in the laboratory, in order that the parasites which emerged from the earwigs could be collected.

The collection of earwigs was commenced on 13th September 1926. Previous investigations by Altson had indicated that the percentage of parasitism decreased in October, so that it was desirable to secure the maximum number of earwigs in a minimum period of time. Further, as the time at the disposal of the writer for this work was limited, detailed investigations were impossible.

The first day was spent making a survey of the Harpenden district with a view to discovering localities likely to yield large quantities of earwigs. Situations examined included crevices of gateposts, underneath the bark of fences and trees, disused sacks found in hedges, etc. In each of these environments a few earwigs were discovered and captured with difficulty. The view that earwigs choose a vertical position when lying-up during the daytime was amply confirmed. The presence of a small hole in the stems of hogweed or cow-parsnip (*Heracleum sphondylium*) (Plate xxx) suggested the possibility of an ideal situation for the earwig's selective requirements. Several of these Umbelliferous plants thus damaged were examined, and in every case quantities of earwigs were present in the hollow stems. The number present in each stem naturally varied, but in three cases where actual counts were taken the number of earwigs present was 44, 56, and 48 respectively. Quantities in excess of these numbers were observed, and seldom was the number below 10. The compact nature of the environment considerably aided the handling of the earwigs. The stem was cut near the ground and each notch severed consecutively; the contents of the internodes were in turn shaken or blown into a bottle container. By this method it was possible to collect large numbers of earwigs (see the following table) in a comparatively short time. The actual time of collecting excluding the journey to the collecting ground was at most 3 hours in the morning and 2½ hours

in the afternoon. The localities visited were chiefly derelict areas of land, hedge-rows of lanes and the headlands of cornfields.

*Numbers of Earwigs collected.*

<i>Date.</i>	<i>Morning.</i>	<i>Afternoon.</i>	<i>Total.</i>
14th September ... ..	300 ...	500 ...	800
15th   "   ... ..	500 ...	500 ...	1,000
16th   "   ... ..	500 ...	400 ...	900
17th   "   ... ..	600 ...	600 ...	1,200
18th   "   ... ..	700 ...	300 ...	1,000
14th October   ... ..	900 ...	— ...	900
			5,800

The hole present in the stems of *Heracleum* is caused by a Lepidopteron, *Dasypholia templi*, Thnb., adults (dead), empty pupa-cases, and parasitised larvae of which were found in the stems. It should be pointed out that only stems thus damaged contained earwigs, there being no evidence that the earwigs themselves bore into the stems. Bearing this point in mind, a small hole was cut near the base of unattacked stems so that entrance was possible. When visited a week or so later the efficiency of such traps was very evident, for large numbers of earwigs were again collected. This method was so successful that stems were brought from the field, treated as mentioned above and then arranged in the hedges surrounding the laboratory. Subsequent inspection yielded quantities of earwigs.

It was interesting to note that many of the stems of *Heracleum* in the vicinity of certain stackyards had been damaged, a longitudinal slit having been bitten down the stem. The explanation for this appears to be that an insectivorous mammal (judging by the teeth marks) had bitten portions of the stem, presumably in order to get at the earwigs. Excreta in the stems proved the previous presence of earwigs.

Each day's collection resulted in a few puparia of *Digonochaeta setipennis* (Plate xxx) being found in the stems of *Heracleum*. These were usually attached near the highest notch of the stem or present in the excreta in the base of the stem. In several instances two puparia were found in a single stem; one instance of three in a stem was noted. On 14th October when stems, previously cut, were revisited 12 puparia were found in those along a short hedge row. This local distribution of parasites was very evident throughout these investigations, for the discovery of one pupa usually led to further discoveries in the vicinity. This is probably due to local oviposition by a single female. The prevalence of the Chalcid hyperparasite, *Dibrachys cavus* (*boucheanus*), renders all puparia collected in the field, and not actually bred from the earwigs, open to suspicion. When shipped to another part of the world each collected puparium—as distinct from those bred from the earwigs—needs to be carefully unpacked on reaching its destination and placed in a separate phial. The latter should be closed with bolting silk, and by this method the escape of any hyperparasites can be prevented. The accidental introduction of *Dibrachys* into a new country with the *Digonochaeta* would very seriously reduce the value of the parasites, and unless material is very scanty it is advisable to transmit only Tachinid puparia actually bred out from the earwigs.

The earwigs were transferred into cages in the insectary. The type of cage used (fig. 1) was one suggested by Dr. Imms, which is extremely useful for work of this nature. It is made of red deal, the measurements being 11 in. by 5½ in. by 9¾ in.; the double glass sliding panels permit easy handling of food, insects and puparia within the cage, and the space available in the base of the cage is convenient for holding sand. The two windows provide for ventilation and are closed by phosphor-bronze gauze of 50 meshes to the linear inch. In some cases bolting silk was used and is

very durable. It is highly important that the mesh is sufficiently fine to exclude such hyperparasites as *Dibrachys cavus*. This Chalcid is even liable to attack the *Digonochaeta* in the laboratory and is extraordinarily skilful in discovering its host. On several occasions Dr. Imms has found this species on the windows of the insectary containing the cages and on one occasion actually crawling over a cage in order to find a means of entry.

The earwig's choice of a vertical position for lying up has to be catered for in the cages. It was found necessary to place rolls of brown paper, cardboard or portions of the stem of *Heracleum* in a vertical position, otherwise the earwigs collect in seething masses in the upper corners of the cage, when the cannibalistic habit is induced. The earwigs were kept in these cages (200 in a cage) for about two months. Their food

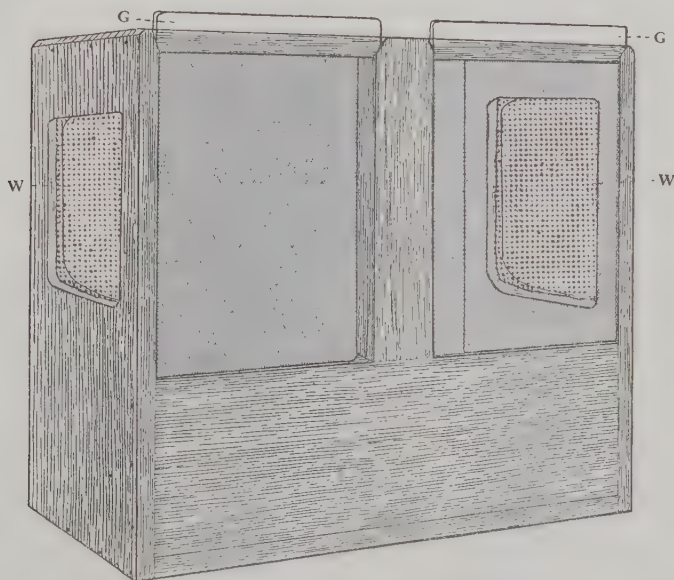


Fig. 1. Type of cage in which earwigs were kept in the insectary.

consisted of moist lettuce, cabbage leaves, sliced carrots and potatoes, etc., and their carnivorous diet was catered for by placing raw meat or mealworms in the cages. Periodically the cages were examined and any puparia of *Digonochaeta* or *Rhacodineura* that were observed were removed and placed in a refrigerator at 42°F. Puparia were found among the food, within the folds of paper, at the base of the stems of *Heracleum*, and some on, or below, the surface of the sand. On 1st December, prior to transmission of the parasites, the cages were finally examined. The sand was carefully sifted through a 2 mm. sieve and the embedded puparia thus removed. The most efficient method adopted for the disposal of the remaining earwigs was that of throwing the insects from both the sieve and the cages into a bucket of water which contained a small quantity of chloroform and a similar amount of benzene. The chloroform, being heavier than water, destroyed any earwigs that sank while the benzene rapidly killed any that floated.



Five per cent. of the earwigs proved to be parasitised. The puparia were packed in moist sphagnum moss and shipped to New Zealand in the cold-storage chamber.

These notes are published in the hope that other workers on biological control may find the information given of some assistance in their collecting work and also that entomologists interested in *Forficula* may avail themselves of this convenient method of securing material.

I am very much indebted to Dr. Imms for valuable suggestions and for the facilities afforded for this work.

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Stems of *Heracleum sphondylium* showing (left) cut stem with earwigs and Tachinid puparia (p) in situ; (right) complete stem with entrance hole of Lepidopterous larva.



# STUDIES ON ANOPHELISM WITHOUT MALARIA IN THE VICINITY OF AMSTERDAM. *W.*

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To the south and south-east of Amsterdam runs the line dividing the northern region "I," where malaria is fairly common, from the southern region "II," where it is rare or absent. *Anopheles maculipennis* is found in both. Perhaps it is more numerous in I; still there is no difficulty in capturing this mosquito in any numbers in animal habitations (stables, pig-sties, cow-sheds, etc.) in II. The geography of the two regions is somewhat different. Region I is characterised by the "polder," a low-lying area often situated below sea-level, drained by numerous ditches filled with floating (*Enteromorpha*, *Lemna*) or partly submerged (*Myriophyllum*, *Ceratophyllum*, *Zanichellia*, *Batrachium*, etc.) vegetation. The water is often brackish. In Region II there are likewise polders, but with fresh-water ditches and on a higher level. The horizontal vegetation shows more *Elodea* and less *Enteromorpha*. Moreover, besides the polders, there are diluvial sandhills. *Anopheles* is common even there, although they have to fly for 2 km. or more to get there, because suitable breeding-places are absent.

Is there a difference between the *Anopheles* of the two regions? That is the problem with which we are dealing here.

## I.—Material and Methods.

Our field of observation includes part of the provinces of North and South Holland and Utrecht, as shown in the accompanying sketch-map; the discs indicate the catching stations, numbered as in the Tables in the text. The sectors in the discs indicate the composition of the Anopheline population:—

Black	=	per cent. of hibernating ♀♀ with wing length above	129
Crossed lines	=	" " " " "	" of 122—129
Vertical lines	=	" " " " "	" " 115—121
White	=	" " " " "	" under 115

The corners outside the discs indicate the chlorine content of the water in the breeding-places surrounding the stations:—

Black	=	1,000 mgr. Cl. per litre or more.
Crossed lines	=	500–999 mgr. " "
White	=	Under 500 mgr. " "

Apart from the discs the following symbols are used:—

Black-spotted area	=	annual incidence of malaria	above	20 per cent.
White-spotted area	=	" " " "	1–5	per cent.
Blank area	=	" " " "	under 1	per cent.
Dotted line	=	line of demarcation between	Region I (north)	and Region II (south).

Our research included:

(1). *Measuring the length of thorax, abdomen and wing, and counting the number of maxillary teeth of hibernating females of A. maculipennis* caught between October 1925 and May 1926, in stables, etc., of numerous stations (see Map) in the Regions I and II. These four measurements we shall indicate in the following pages by the letters *Th*, *Ab*, *W*, and *MT*. We did not measure the whole body-length because of the neck being too retractile. *Th* means the distance between the anterior extremity of the mesonotum and the posterior end of the metanotum. The distance from that point



to the extremity of the cerci constitutes *Ab*. Finally, *W* is the distance between the tip of the wing (between the 2nd and 3rd long veins and the nook between the alula and the inferior costal margin. All these measurements are indicated in units of  $41.7 \mu$ . We have only measured freshly killed mosquitos, because drying shortens even the wing, and not only the fleshy parts of the body. If we had to examine dried specimens (from parts outside the Netherlands) we only measured the wing and multiplied the



Sketch-map of the area investigated near Amsterdam regarding the relation of *Anopheles* to malaria. Scale, 1 : 400,000.

figure observed by a coefficient ranging from 1.009 to 1.017 according to the time elapsed after death. In this and similar cases we feel justified in assuming that  $W$  is a good indicator of the size of the mosquito, because several thousands of measurements showed a high positive correlation between  $W$  and  $Th + Ab$ , ranging from  $+0.804 \pm 0.015$  to  $+0.820 \pm 0.010$ . In counting the number of maxillary teeth ( $MT$ ), we have included all protuberances to be discerned by oil-immersion, even the smallest at the tip of the maxilla, which, by their brown colour or by their conical shape with circular or elliptical base, may be considered as true teeth and not only as angles between notches of the teeth-bearing margin. Sometimes a tooth has two points (bicuspid) and the notch between them may reach so low as to cut the tooth in two. The parts of such a double tooth are situated close together and can be readily recognised. We have counted these as one tooth. We usually examined both maxillae of each female; to calculate the average we included both. There often is a difference of 1—4 between the  $MT$  of the maxillae of one female.

(2). *Taking the same measurements of the females of the spring and summer generations (i.e. from June onward) and of the next winter generation (i.e. from October onward) caught in stables, etc., in some stations of Regions I and II situated at an easy distance for regular visits.*

(3). *Taking the same measurements of males and females bred in the laboratory, under varied external conditions, from eggs deposited by specimens caught in Regions I and II. The larvae were reared in square glass vessels of  $45 \times 23 \times 25$  cm. Their food (except for special experiments) consisted of unicellular green algae scratched from the dry bark of trees (care being taken not to mix parts of the bark with the powdered algae). We included the males because otherwise we should have missed 50 per cent. or more of our material, whereas the summer catches of adults hardly contained more than 9 per cent. of males. The females providing the eggs were made to oviposit in water of the same composition as that in which the larvae were to be reared subsequently. For this purpose the former were kept in cages  $45 \times 30 \times 50$  cm., with walls of wood (with an opening to put a human arm through), glass and wire-gauze, and were fed daily on human blood (always the same person, viz. one of us: de B.), either during the day or at night.*

(4). *Estimating the comparative avidity for human blood of the females of both regions.*—This was done by feeding them in the cages as mentioned above, noting at each meal the number present and that of the females which fed. It is true that they were induced to bite much more readily when they were put in small cylindrical glass jars of  $11 \times 7$  cm., with the opening covered with gauze, which could be applied to the human skin and through which the mosquitos were allowed to bite. But the former method approaches natural conditions more than the latter, which moreover fails to show small differences in avidity for human blood that are disclosed by the former.

(5). *A comparison of the breeding-places of *A. maculipennis* in both regions with regard to the number of larvae (estimated by the average number of larvae caught in one dip with the usual white enamelled shallow frying-pan, diameter 18 cm.), kind of vegetation and chlorine-content (determined by Mohr's method).*

(6). *Estimating the comparative infectibility, with simple tertian malaria, of Anopheles caught in both regions, by feeding them (in this case of course in the small glass jars mentioned under (4), it being here of paramount importance to induce them to bite in the greatest possible numbers) once or twice on a good gamete-carrier (usually a G.P.I. case) and afterwards daily on a healthy person (de B. or Sw.). They were kept at room temperature ( $17-90^{\circ}\text{C}.$ ). From the fourth day onward, after the infecting meal, the mosquitos that died were examined for zygotes and sporozoites. Three weeks afterwards the survivors were killed and dissected.*

TABLE I.

A-C.: Result of the examination of hibernating females of *Anopheles maculipennis* from the stations indicated by numbers on the map.

Explanation of abbreviations; Th.=length of thorax.

MT.=number of maxillary teeth.

% long wings=% of females with a wing above 129.

Nbr.=number of females examined.

No.=number of station.

Ab.=length of abdomen.

W.=length of wing.

W. rel=id., in relation to Th.+Ab.

A.—Region II. Long <i>Anopheles</i> .							B.—Region Ia. Short <i>Anopheles</i> .							C.—Region Ib. Medium-sized <i>Anopheles</i> .									
No.	Nbr.	Th.	Ab.	W.	W. rel.	% long wings.	MT.	No.	Nbr.	Th.	Ab.	W.	W. rel.	% long wings.	MT.	No.	Nbr.	Th.	Ab.	W.	W. rel.	% long wings.	MT.
15	98	49	89	129	0.93	56	16.7	4	339	44	81	114	0.92	1	17.3	17	163	47	85	122	0.92	7	17.4
26	65	48	87	127	0.94	41	16.9	2	117	44	81	114	0.91	2	17.3	12	193	46	86	120	0.91	7	17.3
28	100	48	87	128	0.94	37	16.7	1	28	44	81	117	0.94	0	—	32	150	46	83	120	0.93	9	17.8
29	20	48	89	128	0.93	35	16.9	3	100	44	82	118	0.91	6	17.3	49	48	—	—	120	—	11	—
30	94	47	87	125	0.93	24	16.8	10	100	45	84	118	0.91	6	17.2	50	50	—	—	121	—	6	—
31	100	48	89	127	0.93	33	17.0	14	61	45	82	117	0.92	2	—	51	69	—	—	121	—	6	—
38	89	48	87	127	0.94	36	16.9	6	48	45	81	118	0.94	2	17.2	53	58	—	—	121	—	9	—
44	63	48	89	128	0.93	44	17.0	7	63	44	81	116	0.92	1	17.4	63	52	—	—	121	—	8	—
46	89	47	87	124	0.92	25	17.1	13	100	46	85	119	0.91	2	17.5	66	58	—	—	119	—	10	—
47	166	47	88	124	0.92	27	17.6	34	100	45	83	118	0.92	2	17.8	67	49	—	—	122	—	16	—
52	51	—	—	126	—	35	—	36	119	46	83	119	0.91	2	18.1	68	100	—	—	121	—	7	—
57	58	—	—	123	—	19	—	37	191	45	81	117	0.92	3	17.7	11	221	47	85	121	0.94	3	17.7
58	62	—	—	125	—	32	—	39	118	45	83	116	0.91	1	17.9	33	111	47	84	121	0.93	5	18.0
59	63	—	—	123	—	28	—	45	69	45	82	118	0.92	6	17.8	55	82	—	—	119	—	7	—
60	48	—	—	130	—	56	—	48	50	—	—	116	—	4	17.6	56	71	—	—	119	—	6	—
25	76	46	85	123	0.94	17	17.6	54	91	—	—	118	—	0	—	64	50	—	—	119	—	8	—
35	89	47	87	123	0.92	28	17.0	62	51	—	—	119	—	2	—	—	—	—	—	—	—	—	—
61	54	—	—	123	—	24	—	65	54	—	—	118	—	0	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	8	96	45	81	117	0.93	1	17.3	—	—	—	—	—	—	—	—

D.—Localities in the Netherlands outside our field of observation.

No.	Province or Country.	Locality.	Malaria. present : +      absent : —	Nbr.	Th.	Ab.	W.	W. rel.	% long wings.	M T.
22	North Brabant	Woensdrecht	—	23	45	81	116	0.92	0	17.5
5	Zealand	Goes	—	157	44	81	116	0.92	1	17.1
27	Friesland	Bolsward	+	52	43	79	114	0.93	1	17.7
40	"	Nieuwe Biltzjil	—	100	46	83	118	0.92	3	17.8
41	"	Leeuwarden	—	100	46	84	121	0.93	12	17.8
42	"	Tietjerk	—	100	46	85	121	0.92	20	17.2
43	"	Bergum	—	100	47	89	126	0.93	29	16.8

E.—Localities outside the Netherlands\*

No.	Province or Country.	Locality.	Malaria. present : +      absent : —	Nbr.	Th.	Ab.	W.	W. rel.	% long wings.	M T.
	Spain	Tortosa	+	100	—	—	110	—	0	16.4
	Macedonia	Prizren	+	110	—	—	124	—	24	16.1
	Dalmatia	Metcović (elutus !)	+	112	—	—	117	—	2	15.1
	Russia	Chaturka	+	88	—	—	126	—	28	17.6
	Rumania	Oltenia	+	70	—	—	123	—	23	16.4
	Palestine	Hedera (elutus !)	+	83	—	—	113	—	0	14.8
	Germany	Hamburg	—	100	—	—	125	—	19	16.6
	England	Sheerness	—	39	—	—	118	—	2	16.8

\* This material was kindly sent us by Prof. Pittaluga, Dr. Sfarčić, Prof. Marzinowski, Prof. Lotz, Prof. Kligler, Prof. Martini and Colonel James.



There can be no doubt that we might have succeeded in increasing the number of infected mosquitos by multiplying the number of infecting meals and by keeping them at a higher temperature, but then we risked obscuring any difference of infectibility (presumably not a very marked one) existing between the two types of *Anopheles*, which we might hope to divulge by rendering the conditions of infection as natural as possible.

(7) *Estimating the incidence of malaria within our field of observation.*—Here we have to rely on the returns of the local medical men collected yearly, since 1920, by the Malaria Commission in North Holland. We have avoided making too minute distinctions and have taken together all municipalities where the approximate incidence was above 20 per cent. and from 1 to 5 per cent. An incidence below 1 per cent. was considered as negative, the returns indicating a figure which is usually too high.

## II.—Morphological Differences of Female *A. maculipennis* caught in the two Regions.

### *Winter Generation 1925–1926.*

A female caught in Region I may be indistinguishable from one in Region II. In both there are large, medium and small individuals. Still, the average size in Region II is larger,\* because of the greater prevalence of *Anopheles* with *W* above 129. Table I (A–C) shows the values for *Th*, *Ab*, *W* and *MT* of females of the winter generation caught in animal habitations§ between 28th Oct. 1925, and 12th May 1926. The map shows the same in a graphic form. We examined the winter generation only, because this offers the homogeneous material (with regard to age and time of emergence) indispensable when making comparisons.

We have distinguished between long (*W* above 122, with a percentage of long wings, *i.e.* longer than 129, above 16), medium (*W* = 119–122, with a percentage of long wings above 3), and short type (*W* up to 118 or 119, with a percentage of long wings under 3). The map shows that the first group has a distinct field of distribution: the medium and short types are not so well separated from each other, although the latter has a tendency to centre around Amsterdam. Some stations of the former appear as a transition between areas of the short and long types (32, 49, 53, 66, 67), but others cannot be considered in this way.

Considering each of the three groups as a whole we find the following averages:—

TABLE II.

Type.	<i>W</i> .	<i>Th</i> .	<i>W</i> rel.	<i>MT</i> .
Long (or "lo") ...	125.53	47.61	0.931	17.05
Medium (or "me") ...	120.36	46.41	0.919	17.62
Short (or "sh") ...	116.32	44.59	0.919	17.47

\* Van Thiel has already drawn attention to the fact that *Anopheles* from the stations marked here as 15 are larger than those from station 12, and these larger than the mosquitos from station 27. He also noted the insignificant positive correlation between *W* and *MT* (Arch. Sch. Trop. Hyg. xxx, Beih. i, 1926, p. 70).

§There was no difference between house and stable mosquitos, at least not around Amsterdam:—

Of 546 house *Anopheles*: *Th* 45; *Ab* 82; *W* 117; *MT* 17.3

Of 571 stable *Anopheles*: *Th* 45; *Ab* 83; *W* 117; *MT* 17.3

and the following differences :—

TABLE III.

Difference of	Between the types :			Relation : $\frac{\text{Difference}}{3 \times \text{average error}}$		
	Lo <sup>1</sup> —Sh <sup>2</sup>	Lo—Me <sup>3</sup>	Me—Sh.	Lo—Sh.	Lo—Me	Me—Sh
Length of the wing ...	$9.21 \pm 0.29$	$5.17 \pm 0.29$	$4.04 \pm 0.27$	10	6	5
Length of the thorax	$3.02 \pm 0.13$	$1.20 \pm 0.16$	$1.82 \pm 0.15$	7	2.3	6
Number of maxillary teeth ... ..	$-0.42 \pm 0.05$	$-0.57 \pm 0.07$	$+0.15 \pm 0.07$	2.7	2.7	0.7

All the differences but one, even those between the long and medium types, surpass the required minimum (thrice the average error). It is true that in each separate station the number of females examined may not always have been sufficient, but this is compensated by the findings in each station being corroborated by the neighbouring ones, *i.e.* by the agglomeration of stations with the same composition of the Anopheline population. Consequently we feel justified in concluding that in our field of observation there are at least two distinct types of *A. maculipennis*: a long-winged one and a short-winged one, the terms long and short wing being used both in an absolute sense and in relation to the body length. Almost every station with the long-winged type lies outside the malarial zone; whereas the majority of those with the short- and medium-winged types lie within it. Still there are many exceptions to this last rule, even within the range of our map, and more so in other parts of the country (Table I,D). Moreover we suspect that elsewhere the long-winged type may be found associated with malaria, as the material from malarious regions around Moscow, in Rumania and Jugo-Slavia, distinctly belonged to this type (Tab. I,E).

The differences between *MT* of the various stations are sometimes considerable. They may exceed the difference between some of the Dutch stations and those of highly malarious centres in southern Europe (*e.g.* in Jugo-Slavia).

Still this character is so variable that it contributes but little to distinguish between the *Anopheles* of Regions I and II, and not at all between the medium- and short-winged forms of Region I. There is a very small positive correlation between *MT* and *W*, *viz.* :—

Region II: long-winged type  $+0.05 \pm 0.03$ , *i.e.* no correlation at all.

Region I: medium-winged type  $0.13 \pm 0.05$  "

Region I: short-winged type  $0.15 \pm 0.03$ , *i.e.* a small positive "correlation.

On the other hand, we have seen in Table II that the long-winged type has the smallest *MT*. If the degree of correlation is made out, not for each individual separately, but on the average figures of each station, we find that *MT* first rises with the rise of *W* and, after reaching a maximum, decreases in the longer-winged groups :—

TABLE IV.

Number of stations.	<i>W</i> .	<i>MT</i> .
6	111-115	17.3
8	116-117	17.5
9	118-119	17.6
6	120-121	17.7
8	122-125	17.3
8	126-129	16.9

Outside the Netherlands *MT* is usually smaller. Even when excluding *A. elutus*, it was only in Russia, England and Germany that we found figures for *MT* comparable with ours; all the others (Southern Europe) are smaller (Table I, E).

### Spring and Summer Generation 1926.

After the hatching of the first spring generation, the female *Anopheles* in our selected stations 4 (Region I), 29 and 60 (Region II) became distinctly larger. But as this occurred in both regions, the difference in size remained. In the following autumn they became smaller again, without, however, sinking to last winter's level.

TABLE V.  
Seasonal Changes in Size.  
(For explanation of abbreviations see TABLE I.).

Station 4. Region I.								Station 29. Region II.							
Date	Nbr.	Th.	Ab.	W.	W. rel.	MT.	% long wings	Date	Nbr.	Th.	Ab.	W.	MT.	W. rel.	% long wings
1925.								1926.							
10.11	73	44	82	114	0.90	17.3	1	3.3	20	48	89	128	0.93	16.9	35
14.12	100	43	80	113	0.92	17.2	1	7.6	130	51	94	131	0.90	16.9	64
1926.								16.7	113	52	96	132	0.88	17.3	68
19.1	100	43	80	115	0.92	—	0	4.9	60	48	89	125	0.91	17.2	28
10.3	66	—	—	116	—	—	1	18.10	100	49	93	131	0.92	16.9	65
10.5	100	44	80	115	0.93	17.4	1	15.11	100	49	90	131	0.94	—	62
2.6	130	49	92	125	0.89	17.9	29								
7.7	100	50	93	126	0.89	17.8	26								
7.9	100	45	85	117	0.90	17.7	2								
6.10	100	46	86	122	0.92	18.1	11								
11.11	100	45	84	120	0.92	—	2								
8.12	100	—	—	122	—	17.7	8								
Station 33. Region I.								Station 60. Region II.							
1926.								1926.							
16.3	111	47	84	121	0.93	18.0	5	6.5	48	—	—	130	—	—	56
14.7	47	—	—	125	—	—	26	29.6	150	53	100	136	0.89	17.3	92
25.11	75	—	—	123	—	—	12	16.12	50	—	—	130	—	16.6	52

In several other stations, which we did not examine during the summer, we also found in the next winter that the mosquitos were distinctly larger than in the preceding year. As a consequence of this general increase in size, a map drawn up for the winter generation of 1926-27 would offer a different aspect from the one we publish here. All black sectors would have to be broadened. But so far as we can judge at present, this would not mean the blurring of the line of demarcation between the Regions I and II; on the contrary, it may become all the more distinct.

The curious temporary decrease in size (lasting for one month only) in the beginning of September, which makes the mosquitos almost as small as in the preceding winter (Station 4) or even smaller (Station 29), is a phenomenon that we mention without comment, as we do not know whether it was of general occurrence. During the summer there likewise was a rise in the *MT*. That this was followed by a fall in the autumn we only ascertained (Table V) in Stations 4 and 60. The relative length of the wing (*W. rel.*), which in the winter generation remained fairly constant, decreases in summer in both regions, as a consequence of the abdomen being stretched by the mature ova. In Station 4 the *Ab* of pregnant *Anopheles* was 93, against 90 for the others caught at the same time. In Station 29 these figures are 96 and 92.\*

\* The males in the summer generation were smaller than the females: *W* 111, as against 125 in the females.

How are we to interpret these morphological differences? Are they hereditary or caused by external factors that differ in the two regions? Evidently the milieu has a great influence. This is shown by the difference between the winter and spring generations, which emerge (the former in September, the latter in May) under widely different conditions of temperature and aquatic vegetation. On the other hand, we have seen that the factors causing this difference failed to abolish the difference between the types of *Anopheles* in Regions I and II. While raising the former to the rank of the latter, they increased likewise the size of the long-winged type. It would appear, consequently, that the causes determining the size of our *Anopheles* are of a local and a general nature.

### III. Field Observations on Local Factors, especially Salinity, that may influence the Size of *Anopheles*.

The brackish water in the breeding-places of Region I is among the most notable differences between this and Region II, as may be gathered from Table VI, showing the chlorine content (in July–September 1926), together with the number of larvae per dip, in breeding-places near the catching stations, numbered in the same way as in Table I (A–D) and on the Map.

TABLE VI.

Salinity and number of larvae of breeding-places in the vicinity of our catching stations.

No. = number of the catching station (see Map).

Cl. = number of milligrammes of chlorine per litre.

Lr. = number of larvae per dip.

Region II.			Region I, A.			Region I, B.			Other localities. (see TABLE I).		
No.	Cl.	Lr.	No.	Cl.	Lr.	No.	Cl.	Lr.	No.	Cl.	Lr.
26	25	0.05	4	110	2.0	17	2,650	0.2	27	865	0
26	30	0.25	4	180	2.0	12	1,220	3.0	27	3,370	0.02
28	20	0.3	4	370	10.0	32	2,870	7.0	27	5,650	0.02
29	35	0.5	4	500	4.0	32	420	0.1	40	1,380	1.0
31	45	0.05	4	620	7.0	49	490	1.0	40	2,075	0
38	40	1.0	4	1,080	0.1	50	1,045	1.0	41	115	5.0
44	185	0.05	2	970	0.2	50	3,295	5.0	41	170	4.0
46	915	3.0	13	3,590	0	51	1,775	4.0	42	35	1.0
47a	375	0.12	34	570	5.0	55	930	0.1	42	200	2.0
47b	150	3.0	34	1,150	0.5	56	1,530	0.5	43	75	0.2
47c	760	0.2	39	245	5.0	63	905	0.2			
52	85	0.3	39	3,620	5.0	66	125	1.0			
52	250	0.1	39	3,750	5.0	66	1,215	0.1			
57	145	0.3	45	515	0.2	68	2,860	0			
58	130	0.1	45	940	0.05	33	1,290	6.0			
59	200	0.3	48	1,130	1.0	33	1,300	4.0			
60	205	1.0	54	65	0	33	2,350	8.0			
25	70	1.0	54	1,895	0.1						
25	120	1.0	62	360	0.25						
35	30	0.5	65	45	0.3						
			8	3,040	0.5						
			8	3,210	0.2						

In Region II, 76 per cent. of the breeding-places had less than 200 mg. chlorine per litre. There was none with 1,000 or more. In Region I, on the contrary, 54 per cent. were above 1,000 and 17 per cent. only under 200. This is a remarkable coincidence in favour of the hypothesis that brackish water breeds small *Anopheles*. It is true that the salinity of the breeding-places in Region I, B (medium size) is superior



to that in Region I, A (smallest size); in the former, 62 per cent. of the breeding-places have a chlorine content above 1,000; in the latter, 46 per cent. only. But this is not very important, as the distinction between Regions I, A and I, B is rather artificial. Stations 39 and 45 mark two areas where Region I runs into II like a wedge. Both are on a very low level (more than 4 metres below sea-level) with brackish water (especially in No. 39), except in the north, where they are surrounded on all sides by higher ground with fresh water. This is another coincidence strongly in favour of the above-mentioned hypothesis.

It has been asserted that *Anopheles* bred in brackish water are thereby weakened (the small size being an indication of this condition) and fall an easy victim to malarial infection.\* This is not in accordance with our observation that the breeding-places in the region of long-winged *Anopheles* have less larvae per dip than those in Region I, viz. 0.7 against 2.2. This is more like an indication of a favourable, than of an unfavourable, influence of a certain degree of salinity.

TABLE VII.

*Showing a parallel Increase in the Number of Larvae and the Chlorine Content.†*

Chlorine content in mg. per litre.	Number of breeding-places.	Average number of larvae per dip.
0-99	13	0.4
100-499	20	1.9
500-2,999	28	2.0
3,000-and more	8	2.0

It is difficult to explain this by (supposedly) unfavourable conditions prevailing in the breeding-places of Region II, because we cannot perceive what these conditions are. The horizontal vegetation is abundant, but is a little different from that of Region I; in Region II *Elodea canadensis* and *Hydrochloris morsus-ranae* are the most common; in Region I *Potamogeton pectinatus* and *Myriophyllum*. According to observations we made elsewhere in breeding-places with fresh and brackish water, in a region with short-winged *Anopheles* in this country the breeding-places with a chlorine content under 1,000 had an average pH of 8.2; those with chlorine content above 1,000, of 8.6. The vegetation in both kinds of breeding-places was the same as in our present field of observation.

However this may be, these observations seem to confirm the view that the distribution of short- and long-winged *Anopheles* largely depends on the lesser or higher salinity of the breeding-places.

The following observations point to a conclusion contrary to the former.

We caught pupae from three breeding-places near Station 39, widely differing in chlorine content, and allowed them to hatch in the laboratory, each set separately. Table VIII shows the size of the adults hatched from the three sets between 31st August and 8th September.

\* This seems to be van der Hoeven's opinion as cited by van Thiel (*loc. cit.*). Grassi's theory (Re. Ac. Lincei, xxxi, 1922, p. 535) is quite the opposite, but leads to the same conclusion, as the *Anopheles* bred in brackish water are likewise good carriers—not, however, because of their debility, but in consequence of their particular strength. Alessandrini (in "La Riscicoltura, etc. d' Italia," 1925), on the other hand, declares the big and strong *Anopheles* bred in the fresh and clear water of rice-fields to be harmless.

† This confirms Swellengrebel's previous observation (Ned. Tijdschr. v. Geneesk. 1922, pp. 350-359).

TABLE VIII.

Chlorine content in mg. per litre.	Number of adults hatched.		Females.		Males.	
	Females.	Males.	<i>Th</i>	<i>W</i>	<i>Th</i>	<i>W</i>
330-205	40	20	46	123	44	113
4,515-2,955	34	32	48	125	42	107
3,620-1,685	30	29	47	124	42	106

As the conditions in our laboratory did not influence the pupae in such a way as to make them produce adults differing in size from those occurring in nature (*cf.* next chapter), we conclude that differences in chlorine content, equalling those between many breeding-places in Regions I and II, do not change the size of the adults in an appreciable way.

As is well known, Martini\* explains the difference in size and in number of maxillary teeth between *A. maculipennis* of various countries by the different temperature peculiar to each country. The higher the temperature the smaller the size and the number of teeth. Our observations recorded in Table I, E seem to corroborate this view. They show small Anophelines and a fairly low *MT* in Spain; although the other countries in Southern Europe showed rather long-winged *Anopheles*, still the *MT* was lower than anywhere in the Netherlands. But our observations in the Netherlands do not tally with this hypothesis. The notable differences as to size and number of teeth that we noted in the winter generation within an area of less than 70×40 km., with the even temperature of a maritime climate, compel us to admit that here at least other factors are of much more importance, obscuring any influence of a difference of temperature, supposing that it exists. When comparing the winter and summer generations, any action of the temperature should become manifest. The early spring generation was bred and emerged at a temperature often below that prevailing in September, the time of emergence of the winter generation, whereas the summer generation was bred at a higher temperature; consequently, the spring generation should be the largest, with the greatest *MT*, the summer generation quite the reverse, and the winter generation something between the two. We know that things are different in reality. The winter generation is the smallest and the summer generation equal to or even a little larger than that hatched in spring. It is true that it has a larger *MT* than the winter generation (Table V); but here we have only to recall our observation regarding the correlation between *W* and *MT* (page 357) to show that this does not support the theory, which evidently does not apply to Dutch conditions.§

#### IV. Laboratory Observations on factors that may influence the size of *Anopheles*.

##### 1. Breeding in Fresh and Brackish Water.

We have reared *Anopheles* in the laboratory from eggs deposited by mosquitos caught in Stations 4 (Region I), 29 and 60 (Region II). We bred them in tap-water, pure and with 1,500 mg. Cl.p.l. (NaCl) and in sea-water (from the Zuider Zee, which

\* Arch. f. Sch. u. Trop. Hyg. xxvi, 1922, and xxviii, 1924.

§ One might be tempted to cite in support of Martini's view the small *Anopheles* we found in early September in Stations 4 and 29 (Table V), which were bred in August, the hottest month of the year. Their appearance calls to mind some of Martini's breeding experiments (Centralbl. f. Bakt. lte Abt. xciv, 1925, p. 452). Apart from the fact that this year's hottest period was in early July, there are other reasons, especially the decay of certain kinds of vegetation in the breeding-places occurring in the second half of August with a consequent disturbance of food conditions, which can be made to account for this phenomenon in a much more satisfactory way.

is highly diluted) with 3,000 mg. Cl.p.l. All our breeding experiments are recorded in Table IX, those dealing with the breeding in fresh and brackish water (experiments *a* and *b* of 4, 29 and 60 in Table IX) being combined in Table X. The cultivation in brackish water, compared with that in fresh water, did not yield smaller mosquitos, as we expected, but larger ones. There is no evidence of any influence of brackish water diminishing the size of the mosquitos.

TABLE IX.

No. of the 'catching' station whence the eggs came.		Date and number of the experiments.		Breeding conditions (food : tree- algae).	Number of adults bred.		Females.			Males.	
		Date.	No.		Females.	Males.	Th.	W.	MT.	Th.	W.
4	<i>a</i>	8/7-27/9	5	Fresh water temp. 17°-19°.	180	113	37.9	100.9	17.3	33.3	86.9
	<i>b</i>	21/6-24/8	3	Brackish water temp. 17°-19°	127	129	39.3	104.8	17.6	35.4	92.7
	<i>c</i>	19/7-18/8	2	Fresh water temp. 22°-25°	79	64	37.5	101.2	16.5	32.4	83.6
29	<i>a</i>	10/7-29/9	3	the same { <i>4a</i>	154	100	40.3	113.2	17.2	36.4	97.1
	<i>b</i>	7/7-14/8	3	same { <i>4b</i>	123	117	41.3	111.2	16.7	40.2	102.1
	<i>c</i>	9/7-10/8	2	as { <i>4c</i>	39	45	39.6	103.2	16.9	34.6	87.8
60	<i>a</i>	30/7-17/8	1	the same { <i>4a</i>	116	175	41.3	113.9	15.8	40.2	103.1
	<i>b</i>	7/8-12/8	2	as { <i>4b</i>	29	30	41.9	114.5	16.3	40.9	106.0

TABLE X.

Breeding conditions.				Males.			Females.			
				Number.	Th.	W.	Number.	Th.	W.	MT.
Fresh water	...	...	...	287	36.1	95.0	450	39.6	108.5	16.7
Brackish water	...	...	...	276	38.0	98.1	279	40.4	108.6	17.1

There is some evidence to the contrary, but insufficient to serve as a basis for any further speculation. We conclude that the chlorine content of the water in our breeding experiments has no influence, or that the latter is completely obscured by the action of other factors. With regard to the number of maxillary teeth, the experiments might make us believe that the influence of brackish water does diminish it to a slight extent, if our field experience did not show the contrary.

One might object that the influence of chlorine content would have become manifest if we had only increased the concentration. This is possible, although the few individuals which escaped untimely death in a breeding experiment in 4,500 mg. Cl.p.l. did not prove it (female wings 106.5, male wings 96.0; Station 4). But our object was to explain the difference in size of *Anopheles* in the two regions of our field of observation, and therefore we conformed our experiments to the average limit of variation of the salinity in the breeding-places occurring in these regions.

## 2. Breeding at Higher and Lower Temperatures.

We reared *Anopheles* in fresh water at room temperature (17-19° C.) and in the tropical room at 22-25° (see Table IX and the combined results of experiments *a* and *c* of Nos. 4 and 29 in Table XI).

TABLE XI.

Breeding conditions.	Males.			Females.			
	Number.	Th.	W.	Number.	Th.	W.	MT.
Room temperature ...	211	34.7	91.7	334	39.0	106.6	17.2
Tropical room ...	110	33.4	86.2	118	38.2	101.9	16.7

The differences are slightly more marked than in the preceding experiments, especially with regard to the female wing; moreover, they are in the anticipated direction. The influence causing this difference became likewise manifest by a considerable mortality in the brood, especially among young larvae. This experiment shows for once the distinct correlation between *MT* and *W*, required by Martini's theory. Still we are, no more than before, inclined to accept it to explain the differences between the *Anopheles* in Regions I and II. We even believe that the differences observed do not depend directly on the temperature, but on the changed conditions of nutrition that it causes, manifested by the high mortality of young larvae, by the premature death of the tree algae serving as food, and by the development of moulds on the dead algae.

### 3. Effects of various Kinds of Food.

It is noteworthy that the mosquitos we bred in the laboratory are of much smaller size than those bred in nature. This we only observed if the larvae were kept in the laboratory for the whole or part of the period of larval existence. Pupae caught in nature and allowed to emerge in the laboratory produced adults of normal size.

We first believed this phenomenon to be due to overcrowding in our jars, causing auto-intoxication according to Roubaud's views.\* So we kept the larvae separate, 5 to a jar with a surface of 80 sq. cm., whereas in our largest basins they had 5-6 times less space. The adults hatched by the former were slightly larger:—

			Females.			Males.	
			Th.	W.	MT.	Th.	W.
Dense larval population ...	...	...	39.2	101.5	17.2	34.4	88.5
Sparse larval population ...	...	...	40.2	102.5	17.6	35.2	90.2

but the difference is insignificant, and, in any case, we obtained no normal-sized adults in this way.

Then we supposed that an adult, after emerging, has first to suck blood before attaining its final size. But we have observed that laboratory-bred females, allowed to feed on human blood once or several times before being measured, differ but little and not always in the right way from those killed immediately after emerging.

			First experiment.		Second experiment.
			Th.	W.	W.
Fed ...	...	...	37.7	98.1	114.5
Unfed ...	...	...	40.6	106.3	113.9

Finally we perceived that this difference in size of *Anopheles* bred in nature and in the laboratory is a question of nutrition. The tree algae are evidently insufficient

\* Ann. Inst. Past., xxxvii, 1923, p. 627.



as food to rear a normal-sized strain. When bred in basins containing nothing but the natural vegetation of their breeding-places, such as *Elodea canadensis* or *Chara foetida*, the larvae die before attaining maturity, unless tree algae are added.\* But when this vegetation dies, putrefaction sets in and the surface of the water is covered with a loose flocculent film. Then the surviving larvae commenced to grow and finished by changing into pupae larger than the usual ones bred in the laboratory. They produced adults which in size (females,  $Th=47.4$ ,  $W=125.5$ ; males  $Th=46.5$ ,  $W=116.0$ ) equalled the summer adults from Station 4. This did not always occur. It was observed only when the film contained numerous *Chilomonas paramecium*. If it consisted of Bacteria only, or Infusoria, it had no stimulating effect.

Even a few days of laboratory diet are sufficient to make the larvae produce under-sized adults. Large-sized larvae, caught in nature 2-3 and 4-5 days before pupating and kept on a diet of tree algae, produced adults smaller than those bred from pupae caught in the same breeding-places and then kept in our basins. The difference was the more marked, the longer the period of deficient nutrition had been. If this had lasted for 2-3 days the female  $W$  was 120.9 (123.1 in adults from wild pupae); if it had been prolonged for 4-5 days,  $W$  decreased to 112.3. The wing was only 98.0 long in a parallel culture, where the whole larval life had been spent in our basins.

We did not succeed in procuring a lasting culture of *Chilomonas*. When trying to feed larvae daily on bits of the scum containing *Chilomonas*, we succeeded in increasing the female  $W$  from 98 to 112 but failed in attaining the length of the wing observed in the original *Chilomonas* cultures.

These experiments, summarised in Table XII, clearly demonstrate the influence of food on the size of the adults and explain why our other breeding experiments never produced adults of a normal size.

TABLE XII.

Breeding conditions.		Eggs larvae or pupae from station No.	Number of adults hatched.		Females.		Males.	
			Females.	Males.	$Th.$	$W.$	$Th.$	$W.$
The whole larval existence	1. In a culture of <i>Elodea</i> in which <i>Chilomonas paramecium</i> appeared after some time ...	29	8	4	47.4	125.5	46.5	116.0
	2. Fed on bits of surface scum containing <i>Chilomonas</i> ...	4	14	10	42.7	113.2	37.7	98.5
	3. Fed on tree-algae ...	4	79	62	35.7	98.0	32.1	84.7
Larvae caught in nature and fed on tree-algae during	1. The last 4-5 days before pupation ...	4	11	5	42.1	112.3	37.8	101.0
	2. The last 2-3 days before pupation ...	4	17	15	45.9	120.9	39.8	101.8
Pupae caught in the same place as the larvae, kept under laboratory conditions until they hatched ...		4	60	76	47.1	123.1	41.6	106.9

\* This is no confirmation of the view that *Chara foetida* acts as a larvicide. The mortality is due to scarcity of food. The larvae developed just as well among *Chara* as elsewhere if algae were abundant, and the mortality was just as high among *Elodea* if they were absent.

#### 4. *Breeding Experiments carried out under the same Conditions but starting from Eggs of different Origin.*

Our experiments have shown us two factors (perhaps they are one) determining the size of our laboratory-bred adults: food and temperature. Are they sufficient to explain the difference between the *Anopheles* in Regions I and II? There is no marked divergence in temperature between the two, but it is quite possible that the different salinity of the water in the breeding-places of the two regions may influence indirectly (by changing the microfauna and flora) the size of the mosquitos, which it can not influence directly. If this be true, we should be able to breed *Anopheles* of the same average size, whether we start from the eggs of the long-winged form in Region II or of the short-winged type in Region I, if only we take care to ensure identical conditions with regard to food and temperature. We have complied with this condition, moreover keeping constant the composition of the water (fresh water, pH 6.5-7.7) and still we did not succeed in breeding *Anopheles* of the same average size. Those bred from eggs laid by *Anopheles* inhabiting Region I were smaller and with a higher *MT* than those from Region II. The difference between the two was more marked than that between the lots bred in fresh and brackish water or at high and low temperatures, although breeding at high temperature cannot have failed to exercise a strong and unfavourable influence, as testified by the high mortality among the young larvae. Only natural and artificial food produced differences in the size that exceeded those due to a different origin.

This last mentioned point should make us cautious in interpreting the results of these breeding experiments. We believe that we controlled the food-factor; this only justifies our conclusion that the difference in size of the mosquitos bred from eggs from Regions I and II is not caused by external influences, but by internal hereditary factors. But did we control the food? Was there never a spontaneous growth of micro-organisms changing the conditions of nutrition in our basins? We believe that there has been. In three of our breeding experiments in fresh water with mosquitos from Region I, 131 females showed a *W* of 101.5-102.5; two others showed the aberrant figures of 114.6 and 93.3 in 12 and 37 females respectively. Three similar breeding experiments with mosquitos from Region II showed a *W* of 111.2-113.9 in 241 females; a fourth had a *W* of 121.1 in 29 females. Breeding in brackish water of 1,500 mg. Cl. yielded results more divergent still. The females from Region I had *W* 104.7 in one experiment and *W* 94.1 in another. The females from Region II had an average *W* in two experiments ranging from 103.9 to 121.3. On the other hand, breeding in sea-water of 3,000 mg. Cl. yielded a very uniform result, all broods having a *W* between 111 and 113. In order to ensure an exact comparison between the breeding experiments, starting from eggs of Region I on the one hand and of Region II on the other, we should not only exclude the breeding results in brackish water but also the aberrant results in fresh water. Table XIII shows the result of the breeding of mosquitos of different origin under the same external conditions, with-out and with this correction. The difference it makes is but slight, as is shown in Table XIV, which compares the difference in the average size of males and females taken together, caused by external circumstances and by difference in origin.

TABLE XIII.

Origin of the brood.	Without correction.							After correction.						
	Males.			Females.				Males.			Females.			
	No.	Th.	W.	No.	Th.	W.	MT.	No.	Th.	W.	No.	Th.	W.	MT.
Region I	322	39.1	101.2	422	40.9	112.9	16.5	159	37.4	98.4	241	40.6	112.6	16.4
Region II	242	34.4	90.0	307	37.9	102.5	17.4	88	33.8	87.7	131	38.7	101.8	17.2

TABLE XIV.

Breeding conditions, the effect of which is to be compared.	Difference between the adults bred under each opposite set of conditions; the difference of the first set supposed to be 1.		
	Males and Females.		Females.
	Th.	W.	MT.
Brackish and fresh water ... ..	+1	+1	+1
Low and high temperature ... ..	+0.7	+3.2	+1.2
Natural and artificial food ... ..	+6.8	+12.1	—
Long- and short-winged origin { <i>a</i> uncorrected ... ..	+2.7	+6.7	-2.2
{ <i>b</i> corrected ... ..	+1.9	+6.7	-1.5

This result of our breeding experiments with *Anopheles* of different origin, *viz.*, from the two regions we have examined where we found the long- and short-winged types of mosquitos, shows us that it is impossible to eliminate this morphological difference in the descendants by breeding them under conditions similar with respect to those factors which have been proved to influence the size of the mosquitos. We consequently feel justified in assuming that there is in these types an inherent factor, independent of the external circumstances, determining the size, *i.e.*, a hereditary factor. These two types are either two hereditary distinct races, differing by their size, or two associations of a number of races, but mixed in unequal proportions, the larger-sized ones dominating in one region and the smaller ones in the other.\*

#### V. Feeding Habits and Hibernation of Adults.

The *Anopheles* of Regions I and II are not only separated by morphological differences, but also by biological ones, *viz.*, the behaviour of the adults with regard to food and hibernation.

During the summer of 1926, 60–80 per cent. of the females in animal habitations of both regions had taken blood recently. But at the onset of the autumn they behaved differently. In September–November the females of Region I kept close to the animals; they continued to suck blood, although in decreasing frequency, but not more than 1–10 per cent. became fat. The females of Region II did not feed any more, or but rarely; the majority did not stay close to the animals, but in cold out-houses, attics, etc.; 40 per cent. or more, often 90–100 per cent. among them were fat.

In Stations 4 and 29 we found:—

TABLE XV.

Month.	Station 4.					Station 29.				
	Number of females.	With blood.	Per cent.	Fat.	Per cent.	Number of females.	With blood.	Per cent.	Fat.	Per cent.
May ... ..	100	60	60	—	—	—	—	—	—	—
June ... ..	130	114	87	—	—	150	116	77	—	—
July ... ..	100	73	73	—	—	113	70	62	—	—
October ... ..	100	78	78	—	—	100	0	0	94	94
November ... ..	200	59	29	21	10	100	1	1	90	90

\* The racial difference between the Anopheline population of Regions I and II explains the absence of correlation between size and number of maxillary teeth. This correlation can be demonstrated (by the method detailed on p. 357), but only within the limits of Region I, *i.e.*, with regard to one race (or population) only; whereas it fails to show if no care is taken to consider each race (or population) separately.

These are the two kinds of hibernation which Grassi\* described as semi-hibernation and complete hibernation. The former he observed in the vicinity of Rome, the latter in Northern Italy. Whatever may be the reason for the prevalence of one or the other during winter in other countries, it is certain that in the Netherlands at least temperature cannot be of much importance, as the two kinds of hibernation may be observed in localities not farther distant from each other than Rome from Fiumicino.

In the stations of Region I, situated around Amsterdam, we have established, since 1920, the percentage of females which had fed recently in houses and stables. During the summer the first figure is hardly inferior to the second. Both tend to increase from January onward and usually reach their maximum in June. During the ascent and descent there may occur secondary maxima in spring and autumn. In 1926 only, the latter is of some significance (Table XVI).

TABLE XVI.

Percentage of Females with Blood in their Stomachs in Houses (H) and Stables (S.).  
(The numbers examined were never less than 100 a month).

Month.	1920.		1921.		1922.		1923.		1924.		1925.		1926.	
	H.	S.	H.	S.	H.	S.	H.	S.	H.	S.	H.	S.	H.	S.
January ... ..	—	—	8	23	4	15	15	22	4	11	5	2	—	—
February ... ..	—	—	18	31	6	18	11	30	17	30	11	31	4	32
March ... ..	42	—	33	49	28	38	29	32	39	38	28	38	11	29
April ... ..	32	—	59	60	47	30	48	49	58	60	50	—	30	50
May ... ..	49	—	51	60	56	30	—	65	54	76	—	—	—	60
June ... ..	51	65	59	73	63	66	76	71	63	65	80	50	—	88
July ... ..	43	64	50	68	55	63	60	63	56	70	36	—	—	73
August ... ..	26	56	50	61	28	35	81	85	53	76	—	—	—	—
September ... ..	31	45	37	54	37	35	—	43	39	48	33	—	3	37
October ... ..	11	37	30	35	35	29	39	33	21	31	24	42	16	60
November ... ..	10	22	15	19	14	27	9	16	17	7	3	11	42	11
December ... ..	—	11	12	20	5	18	6	6	—	4	0	4	—	—

In Region II our experience with regard to *Anopheles* caught in stables is limited to 1926, and we do not know anything concerning mosquitos caught in houses. This is caused by the absence of malaria; the inhabitants are not accustomed to see people entering their houses to catch mosquitos and resent this intrusion.†

To fill as much as possible this gap in our knowledge, we have made some experiments to compare the readiness with which *Anopheles* of both regions take to human blood. The method employed is described in Section I. The mosquitos were allowed to bite at night and during the daytime. As a general result we found:

TABLE XVII.

Percentage of <i>Anopheles</i> biting man, caught in			
Time of feeding.	Region I.	Region II.	
	Station 4.	Station 29.	Station 60.
At night ... ..	25.3	10.1	13.0
In daytime ... ..	6.9	1.0	9.8

\* Grassi, Ann. d'Igiene xxxii, 1923, p. 438.

† Consequently we cannot give, for the present, any particulars concerning the comparative incidence of *A. maculipennis* in houses and stables of Region II. As Swellengrebel (Ned. Tijdschr. v. Geneesk. 1924, 2de Helt, pp. 1112-1125) has shown for the immediate vicinity of Amsterdam, the proportion of the number of *Anopheles* caught in houses and stables ranges from 1 to 85 in 1920, to 1 to 178 in 1922.



The difference detected here disappears when the mosquitos are kept in small glass jars and allowed to feed through the gauze covering. § In the month of June, in the large cages where *Anopheles* were kept and allowed to feed, 12 per cent. (Region I) and 0·8 per cent. (Region II) took human blood during the day. But 39 per cent. and 44 per cent. respectively did so in the small jars. In September, however, only 18 per cent. of the long-winged mosquitos fed in these jars, whereas the short-winged ones, on the contrary, were extremely voracious when being fed in this way (77 per cent. of them took blood). We believe the experiments in the large cages to approximate more to natural conditions than the others, and consequently only take account of the former.

The results shown in Table XVII might lead us to assume a greater avidity for human blood in mosquitos from Region I, at least during the night. But if we take account of the result obtained in each month, we observe the mosquitos of Regions I and II to be different in this respect only in spring and autumn, at least when fed at night (Table XVIII).

TABLE XVIII.

Month.	Region I.				Region II.							
	Station 4.				Station 29.				Station 60.			
	Females.			Mor- tality.*	Females.			Mor- tality.*	Females.			Mor- tality.*
	Total.	Biting.			Total.	Biting.			Total.	Biting.		
		Total.	%			Total.	%			Total.	%	
June ...	217	42	19·4	6·1	158	3	1·9	22·5	90	4	4·4	—
July ...	—	—	—	—	890	90	10·1	11·2	268	46	17·2	10·6
August	1,492	374	25·1	2·9	155	34	21·9	11·4	—	—	—	—
Sept. ...	1,670	421	25·2	3·0	295	25	8·5	10·0	—	—	—	—
October	170†	63	37·0	—	—	—	—	—	—	—	—	—

\* Average daily number of deaths expressed as a percentage of the original number of females.

† These were females that had been kept fasting for a week.

The high mortality will be noted in the cages containing *Anopheles* from Region II, as compared with those of Region I. The mortality among the latter was so low that we succeeded in keeping one single lot alive for months at a time, and always in the same cage, by feeding it daily on human blood. But there is nothing particular in this mortality; it is simply a consequence of the refusal to feed, for the mosquitos from Region I died just as quickly when they were allowed to feed during the daytime only (mortality of 12·5 per cent. in July and August among the mosquitos of Station 4, and of 11·6 and 12 per cent. among those of Station 29).

In view of what has been said regarding the percentage of females containing blood caught in the stables in summer and autumn in both regions, there is nothing surprising in the sudden decrease in the number of mosquitos from Region II sucking blood in our cages. It is not that they decline to take human blood, but any kind of blood whatever, because they are entering the state of complete hibernation. But in June things are different. At that time cattle are attacked by the maximum number of mosquitos in both regions, and there is no trace left of the hibernal lack of appetite in Region II. In that month there really seems to be a tendency to avoid human blood in the mosquitos of that region, which is much less marked in the mosquitos of Region I. Still, this conclusion must be accepted with some reserve. We know that it is precisely in June that we find in houses the maximum number of females with blood in their stomachs, whereas in our experiments, even among the mosquitos of Region I, the readiness to suck human blood is less in June than in the

§ When using this method the difference of individual attractiveness for mosquitos of various human donors disappears likewise.

subsequent months. Possibly the conditions prevailing in our experiments in early summer tended to diminish the appetite of the caged females.

Summarising, we may state that our experiments show a minimum of avidity towards human blood in June among the *Anopheles* of both regions, those of Region II being the less ready to take it. In the subsequent months this avidity increases, so as to become equal for both regions in August. At the beginning of the autumn it remains high in the mosquitos of Region I, whereas the others commence their complete hibernation.

#### VI. Infectibility with Parasites of Simple Tertian.

The results of our experiments to infect the *Anopheles* of both regions by allowing them to bite carriers of simple tertian gametes are summarised in Table XIX.

TABLE XIX.

No.	Number of ♂ gametes per cub. mm. (except in No. 1, where the total number of ♀ and ♂ is given).	<i>Anopheles</i> from Station.	Number of times they bit the carrier.	Number of <i>Anopheles</i> that survived long enough to be dissected.	Number found infected.	Per cent.
1	297	4	3	20	5	—
2	297	60	3	13	7	—
	98	4	1	6	1	—
	98	60	1	4	1	—
3	16	4	1	8	2	—
	16	29	1	17	0	—
4	850	4	1	12	2	—
	850	29	1	4	1	—
5	210	4	2	10	3	—
	210	29	2	9	2	—
	210	Biesbosch*	2	4	0	—
6	164	4	2	21	0	—
	164	29	2	11	0	—
	164	60	2	6	1	—
7	672	4	1	31	1	—
	672	29	2	6	0	—
8	672	4	1	23	3	—
	672	29	1	7	0	—
	672	60	1	12	0	—
Total.		4	—	131	17	13
		29	—	54	3	5
		60	—	35	9	26
		Region I	—	131	17	13
		Region II	—	93	12	13

\* A fresh water region without malaria, outside our field of observation. We include it here in Region II.

The gamete carrier of Experiment 1 was a normal individual suffering from a naturally acquired simple tertian; all the others were G. P. I. cases under malarial treatment. The strain had always been transmitted by blood inoculation since 1922 through a course of no more than 20 passages. In other respects also Experiment 1 is exceptional: it is the only one which yielded a fair number of infected mosquitos. Whether this is due to the fact that this is the only case in which the mosquitos were allowed to feed thrice or whether in the G. P. I. carriers the gametes had become less viable, in consequence of a too long continued asexual cycle of development, is a point we cannot decide. The number of male gametes the carrier showed in his blood did not appear to be of much influence (provided that we exclude Experiment 1):—

With 16-98 ♂ gametes per cub. mm.	35 mosquitos showed infection in	4=11%
With 164-210 ♂ " " "	61 " " "	6=10%
With 672-850 ♂ " " "	95 " " "	7=7%

Our experiments do not show any difference of infectibility of the mosquitos from the two regions. There certainly is a great difference between the *Anopheles* from Stations 29 and 60 of Region II, but this is partly due to the absence of the former in Experiment 1. If we exclude the latter, the difference becomes much less marked. But at the same time there appears to be a slight difference between Regions I and II in favour of the former :—

Without Expt. 1, Region I, no 4 :	12 infected <i>Anopheles</i> out of 111=11%
„ „ Region II, nos. 29 and 60 :	5 „ „ „ 76= 6%
„ „ „ „ 29 :	3 „ „ „ 54= 5%
„ „ „ „ 60 :	2 „ „ „ 22= 9%

Considering the small numbers resulting from this differentiation, we cannot feel justified in changing our previous conclusion.

### Summary.

The question to which we have tried to find an answer is why malaria is almost absent in the southern region (II) within our field of observation, whereas it is endemic in the northern (I). We found *Anopheles* slightly less frequent in the former, but the difference is irrelevant, and the density of the Anopheline population in Region II is considerable, compared with almost all the European malarious countries we visited and where *A. maculipennis* is the local vector.

If this difference in the incidence of malaria is at all caused by a difference of the Anopheline faunas of the two regions (which need not be the case), then the biological distinctions are the only important ones. Morphological differences cannot interest us unless they are correlated with the former. Still we began by studying the latter, because they are easier to observe and to measure.

We did not find any morphological character by which we could distinguish between any two individuals from the respective regions. All we could demonstrate is : (1) the larger size of the *Anopheles* of the stations in Region II as compared with Region I ; (2) that this difference in size is not only due to external influences (of the food notably, perhaps also of the salinity of the water, which, however, is not direct, but may act through the medium of the food ; we failed to demonstrate an influence of the temperature) but also to the hereditary composition of the Anopheline population being different for each region.

Up till now we found the following biological characters correlated with the morphological ones.

Biological character.	Small-sized <i>Anopheles</i> of Region I.	Large-sized <i>Anopheles</i> of Region II.
Hibernation.	Semi-hibernation ; occurring in inhabited houses or stables. Blood-sucking continues all the winter. Fat mosquitos scanty.	True hibernation ; beginning in early autumn, in uninhabited localities. No feeding. Numerous fat mosquitos.
Readiness to suck human blood.	Shows but little change during the course of the summer and early autumn.	Begins at a low level in June ; almost equals that of the other group in August ; completely disappears in early autumn.
Blood feeding in stables under natural conditions.	Reaches its maximum in June, with slight variations from April till October.	The same, except for the complete cessation of feeding at the commencement of October.
Infectibility.	No appreciable	difference.

Supposing further studies to confirm the existence of this correlation between the morphological and biological characters, we may ask whether these observations furnish us with the answer to our question, namely, the cause of anophelism without malaria in the country surrounding Amsterdam. The morphological difference does not explain anything, and the infectibility is the same; consequently there only remain the characters relating to nutrition and hibernation.

The annual malarial epidemic in the Netherlands usually occurs in spring, with a maximum in May or June. In June the *Anopheles* of Region II are less eager for human blood than those of Region I, and this difference is still more marked in autumn because of the various modes of hibernation.

The annual course of the epidemic suggests that the maximum of Anopheline infection occurs from April till June. Supposing that the avidity for human blood of *Anopheles* in Region II is not greater in April or May than it is in June, we may conclude that these mosquitos cannot carry much malaria during the height of the malarial season.

It is true that we do not find infected mosquitos in Region I at this season, at least not later than April, as we have shown elsewhere.\* But this may be due to the greater activity of the mosquitos in summer, in consequence of which we fail to detect the infected ones in the localities where we look for them, i.e., the malaria houses.

On the other hand, our previous observations† showed that *A. maculipennis* is found infected regularly in autumn and winter and that there is nothing to prevent this infection from being transmitted to man during the winter, except for the inevitable assumption that human infection resulting from the bites of these mosquitos remains latent at least till February. We do not know what percentage of the yearly malaria cases may be ascribed to these winter infections. According to Korteweg's\* and Honig's‡ investigations it is a considerable one. In any case, *Anopheles* of Region II cannot take any part in causing these winter infections, as a consequence of their habit of complete hibernation.

Absence of eagerness to suck human blood in early summer, and early and complete hibernation in autumn, are the two circumstances emerging from our investigations as possible causes of the absence of malaria in the Anopheline Region II. In the case of further research pointing out these factors as the principal causes of this phenomenon, our conclusions do not imply in the least that they will operate in the same way in other countries where *A. maculipennis* is the principal vector. Even within our own country we should abstain from any generalisation; the existence of short-winged *Anopheles* in the malaria-free parts of the province of Zeeland warns us against any such assumption.

To our mind the solution of the problem of anophelism without malaria is being retarded by the desire to find a uniform explanation, applicable alike to all cases. This tendency is based on the supposition that the phenomena included under that name are all identical. We believe that this is a mistake, and that each country, perhaps each province, will have to work out its own peculiar solution. We should not be surprised if the end would prove that the expression "anophelism without paludism," as used in various countries, comprises phenomena of so widely divergent a nature that one will be compelled to drop it in order to avoid the confusion necessarily arising from its use.

\* Swellengrebel, Ned. Tijds. v. Geneesk. 1924, 2nd half, pp. 750-763.

† Korteweg, Geneesk. Bladen, 22e, Reeks No. 1, 1920.

‡ Honig, Thesis of the Medical Faculty, Univ. of Amsterdam, 1921.





THE BIONOMICS OF THE LESSER BULB FLIES, *EUMERUS*  
*STRIGATUS*, FLYN., AND *EUMERUS TUBERCULATUS*,  
 ROND., IN SOUTH-WEST ENGLAND.

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(PLATES XXXI-XXXII.)

## Introduction.

The larvae of certain flies belonging to the family SYRPHIDAE have long been recognised as plant pests. *Merodon equestris*, Fab., was recorded in Great Britain as far back as 1869, having probably been imported in narcissus bulbs from Holland (Verrall<sup>5</sup>). This fly is now universally known as the "Large Narcissus Fly," the larvae causing serious losses in nearly every locality where the narcissus is grown commercially. More recently flies of the genus *Eumerus* have been associated with a type of injury very similar to that caused by the larger fly, and the larvae have been recorded on a variety of host-plants in Europe and America. Chief among these hosts may be included narcissus, onion, hyacinth, parsnip, iris, and potato. The flies are commonly referred to as "Lesser Bulb Flies" or alternatively in some parts of North America, where they were first recorded as European introductions in 1904, as "Lunate Onion Flies."

There has been in the past some considerable confusion concerning these flies, both as regards the synonymy of the actual species concerned with the damage and also regarding the extent to which the larvae may be considered primary pests of the plants on which they are found, as opposed to being merely scavengers, feeding only on material damaged by some other organism. The aim of this paper is to elucidate as far as possible the position with regard to these points, at least in the British Isles, and further to review some possible methods of preventing or controlling attacks.

In 1901 Verrall<sup>5</sup>, described three British species of *Eumerus*, viz., *E. sabulon*, Fall., *E. ornatus*, Meig., and *E. strigatus*, Flyn. The first two species are outside the scope of the present work, but the third species *E. strigatus*, he considered to be synonymous with the previously described Continental forms *E. aeneus*, Mcq., and *E. lunulatus*, Meig. Inspection of economic literature shows that since 1901 the fly has been reported under all three names from most European countries, including Great Britain, and from North America, on the various host-plants above enumerated. In 1920, Collin<sup>1</sup>, described and figured *E. tuberculatus*, Rond., as an addition to the British list of species. Rondani first described this species in 1857<sup>3</sup>, and it was not again recognised or recorded until the description by Collin. This was made from specimens bred from narcissus bulbs by Fryer<sup>1</sup>, who had considered that the larvae in these bulbs differed from those with which he was familiar and which were presumably *E. strigatus*. Since that date the species has occurred in narcissus bulbs in Canada and the United States of America and has frequently been recorded in this country.

Examination by the writer of flies bred from nearly 200 bulb samples during the past two and a half years, from various parts of England, but more particularly from Devon, Cornwall and the Isles of Scilly, and from Holland, has shown that in the vast majority of cases, on narcissus at least, the damage is attributable to *E. tuberculatus*. At the same time *E. strigatus* is by no means uncommon. It would be most instructive to make an examination of the specimens, where available in previously recorded cases, in order to see which species actually caused the injury, as

it seems highly probable that numbers of these records attributed to the latter species in reality relate to the former. In no case in the experiments under notice were the two species bred from the same consignment of bulbs, and nearly 90 per cent. of the total cases recorded were attributable to *E. tuberculatus*.

In view of the fact that damage by these flies has become increasingly severe annually and that no accurate information has been forthcoming as to the extent to which they are able to attack entirely healthy bulbs, an attempt has been made to elucidate the life-history fully and to review the possibility of using new methods of control. Most of the experimental work here described was carried out with *E. tuberculatus*, as being the species chiefly concerned; however, no difference between the life-histories of the two species was discernible, and for all practical purposes they may certainly be considered together.

### ***Eumerus tuberculatus*, Rond.**

It is in the adult stage only that the two species, *E. strigatus* and *E. tuberculatus*, may be separated with any degree of certainty, no reliable character having been found in the egg, larval or pupal stages. The descriptions here given have been made from specimens of the latter species.

*Adult* (Plate xxxi, figs. 1, 2).—A detailed description of this is given by Collin<sup>1</sup>, who at the same time enumerates the characters which serve to distinguish it from the former species.

*Egg* (Plate xxxii, fig. 3).—White, somewhat shining, elongate oval, tapering at one end. Surface of chorion sculptured longitudinally. Length, 0.7 m.m.

*Larva* (Plate xxxii, fig. 1).—Subcylindrical, greyish white. Anterior spiracles dorsal and widely separated. Posterior pair fused and prominent, chestnut-brown in colour. Integument clothed with minute brown scattered spines, and the segments bearing rows of small tubercles carrying larger but otherwise similar spines. On the last pseudo-segment, on each side of the posterior spiracular process and slightly ventral to it, a large tubercle. Slightly dorsal to this and on the penultimate pseudo-segment, a small twin tubercle, each twin terminating in a cluster of curved spines. More dorsal still and on the same pseudo-segment, a third tubercle intermediate in size between the preceding ones. Length, 7–9 mm.

It was not found possible accurately to separate the larvae of the two species by means of any definite characters, but at the same time, as indicated by Collin<sup>1</sup>, the skin armature is on the whole more pronounced in *E. strigatus*.

*Pupa* (Plate xxxii, fig. 2).—Somewhat pear-shaped, integument tough; yellowish white, darkening later. Anterior spiracles not visible in freshly formed pupa, but extruded later. Posterior spiracular process prominent. Posterior tubercles present and skin armature similar to that of the larva, but less prominent. Length, 6–7 mm.

### **Seasonal Biology.**

Before any attempt could be made to estimate the real importance of and to devise new methods of controlling attacks by "Lesser Bulb Flies," it was obviously necessary to obtain full and accurate data concerning the life-histories of the species concerned.

In the summer of 1925 a consignment of bulbs heavily infested with the larvae of *E. tuberculatus* was obtained and placed in a large insectary, in which large numbers of both diseased and healthy bulbs were already growing. From that time until the end of October 1926 the progeny of these larvae were under constant observation, and at the same time their activities were checked at frequent intervals with those of both species of flies in the field. It may be stated at once that the large size and miscellaneous contents of the insectary provided conditions almost identical with

those obtaining in the open, and that no real discrepancy between the behaviour of its occupants and of flies free outside was traced. The only point worthy of note in this respect being that the captives were a little less ready to oviposit, which may easily have been due to the difficulty experienced in providing a normal diet for the adult flies. Mention might here be made of the similarity found in the habits of the two species of flies under consideration. As already indicated, it is not possible to separate the larvae with certainty, and it was only by isolating batches of larvae from different consignments of bulbs and breeding out the adults that definite information as to the species concerned could be obtained. Larvae of the two species bred from flies isolated in this way were found to behave identically when subjected to like conditions, as regards feeding habits, time occupied in metamorphosis, etc., and the only possible conclusion to be drawn is that the species are identical in habits. At the same time, as previously pointed out, one species, viz., *E. tuberculatus*, is of far more frequent occurrence, at least in the south-west of England.

Turning now to the question of the number of generations of the fly produced in the year, a point concerning which considerable doubt has been expressed at various times, we may take it that *E. tuberculatus* at least, and possibly *E. strigatus*, is indigenous to the south of Europe, having subsequently spread northwards. It is therefore quite reasonable to assume that the normal cycle of generations might be to a considerable extent upset. Consideration of the following indicates that this is actually the case.

All infested bulbs examined between the middle of September and the end of March will be found to contain larvae. The bulk of these are practically fully fed, and they will do little more feeding before pupating in April. A few, however, are found to be only about one-quarter grown, and these will feed vigorously in the spring and may not pupate until well into May. The last date on which an overwintering larva has been actually recorded in a bulb is 15th May. The bulk of the larvae have, however, pupated by about 20th April. Adults commence to emerge about 12th May, emergence becoming general by the end of the month and continuing throughout June, after which time this generation is almost exhausted. In passing, it may be noted that both in the insectary and in the field emergence of males was noted approximately three days earlier than that of the females.

Copulation occurs two to three days after emergence, oviposition commencing two days later. The earliest date on which eggs were actually seen was 24th May. These hatched after two days and the resultant larvae pupated around 20th June. Definite second brood adults were first obtained from these pupae on 6th July. These adults immediately copulated and oviposited, their progeny continuing to emerge as adults right up to the end of September. It seems to be very doubtful as to whether any flies of this generation produce yet another brood, as oviposition was very rare after the end of July, although the last recorded date for this is as late as 23rd August, in spite of copulation continuing to take place on warm days well into September. It is certain that the bulk of the larvae from these second brood adults feed up slowly and pass the winter in the bulbs before pupating. As just pointed out, however, some do feed up rapidly, pupate and emerge as adults from the end of August until as late as early October. We must not lose sight of the larvae which were only partly grown during the previous winter. These feed up rapidly in the spring and emerge as adults along with the normal second brood. They are found to behave in a similar way to these, some of their progeny emerging as adults during the same autumn and others overwintering as larvae.

We see from the above that, while some few of the flies complete but one generation in the year, others produce two, and yet others a partial third. It has not been possible to ascribe any particular cause to the varying rates at which the larvae feed, such rates being the deciding factors in determining the length of a generation. In some cases eggs laid by an individual fly have produced autumn adults and overwintering



larvae in one and the same bulb. One point is clear, however, and that is that the complete winter is never passed as a pupa. The pupal period is relatively a short one, in June and July amounting usually to 14 days, and in September to not more than 23 days. One factor governing the time at which pupation occurs is undoubtedly the moisture content of the bulb. The larva naturally lives in an exceedingly moist surrounding, and if the bulb tends to dry up and at the same time the temperature is reasonably high, pupation usually takes place. Again, migration of the larvae through the soil in search of food has not been observed, and in the event of large numbers being present in a small or moderate-sized bulb, the food supply may be exhausted before all are fully fed. In these circumstances the larvae tend to remain semi-dormant for several weeks or even months before finally pupating and producing somewhat undersized adults. Neither of these explanations can, however, be brought forward as the reason for some larvae pupating in the early autumn and others overwintering, when all have been produced from the same batch of eggs and subjected to identical conditions, unless it be assumed that in the presence of a limited food supply, some larvae manage to consume more than others and thus to mature more rapidly. The real solution appears to lie in the probable southern origin of the fly, the species not yet having become fully adapted to the seasonal changes experienced in this country.

### Detailed Life-history.

The seasonal biology having been discussed it is now proposed to examine in detail the life-history of the individual insects.

*Emergence.*—The adult fly emerges from the pupa by splitting off a circular cap at the anterior end. The soft, grey-coloured fly climbs to a suitable spot and remains inactive until the hardening of the integument is completed. A process occupying something over an hour.

*Copulation.*—This usually occurs from two to three days after emergence and preferably in hot mid-day sunshine. It was never observed to take place when the temperature was below 63° F., but may occur as late as 7.30 p.m. on warm days. The operation may occupy from three to fifteen, but most usually about seven, minutes. The flies wing rapidly around in the sunshine, only a few inches above the ground, settling at frequent intervals. The males, which are on the average the smaller sex, pounce upon the resting females and rapidly vibrate their wings while copulation is actually taking place. One male has been seen to mate with several females when caged, but a female once fertilised avoids further advances.

*Feeding habits and longevity.*—In the field, adult flies have frequently been observed feeding at the flowerheads of various common Umbelliferae and Compositae. In captivity they will feed freely on honey and water, but these should be supplied in separate receptacles, as a mixture tends to ferment and to cause dysentery and premature death. Males in captivity usually lived for about 13 days, females about 15. The longest record being a female that remained alive for 28 days. Attempts to hibernate the adults invariably failed.

*Oviposition.*—Oviposition normally commences two or three days after fertilisation and occurs on warm and dry days only. The female crawls about with the ovipositor extruded and deposits eggs singly or in small groups. It is difficult accurately to determine the number of eggs laid by one individual, but as many as 57 were recorded and it is possible that this number is normally greatly exceeded. The positions chosen for oviposition vary somewhat. In the event of the foliage having died down extensively, it is possible for the fly to crawl down the cavity thus left in the dried earth and to deposit the eggs actually on the bulb itself, several inches below ground-level. This is frequently done. At the same time the eggs are very often laid on the

dried foliage at some distance from the bulb, and quite half of the total number of eggs laid are placed actually on the soil surrounding the bulb-hole, this being the case even when it would have been perfectly easy for the fly to have reached the bulb itself. Heaps of bulbs left on the ground provide a favourite place for oviposition. It seems to be essential for the well-being of the egg that it is placed on reasonably dry material, but at the same time very many of those placed on the surface of the ground are shrivelled by the heat of the sun, and many of the larvae hatching from them perish from drought or heat before they are able to make their way to shelter. As a general rule eggs are not placed more than six inches from a bulb.

*Larval behaviour.*—The eggs hatch within three days of being laid, emergence being from the more pointed end. The young larvae, which on hatching are soft, colourless and very active, immediately make for the nearest bulb. It is noteworthy that those hatching from eggs laid on the soil make no attempt to burrow through it, but travel over the surface towards the cavity surrounding the adjacent bulb-neck, while those emerging on the dried foliage travel down this, towards the neck of the bulb also. Eventually all these larvae arrive at the point where the dried foliage meets the still living neck of the bulb itself. At this point they are found to congregate, undoubtedly attracted by the presence of a certain amount of damp and rotting tissue at the actual point of union. Many larvae commence to feed here and by so doing gradually enlarge the rotted area and are finally able to work down into the heart of the bulb (Pl. xxxii, fig. 1). Larvae emerging from eggs laid actually on the sides of the bulb rarely travel up to the neck before feeding, but tend to congregate around the base and there to find a point of entry, as also do other larvae which fail to find conditions favourable to their making an entrance at the actual bulb-neck. Such a point of entry is occasionally available in the form of a cavity left where a root has died away, or a split where an offset is breaking away from the main bulb. In the case of a bulb already damaged by the attack of eelworms or some other organisms, entry may be made at any suitably damaged point in the bulb. The number of larvae found in a single bulb may vary from 2 or 3 to as many as 200.

Once a hold has been obtained on a bulb, fresh living tissues will also be attacked, the strong rasping mouth-parts being easily capable of tearing down such tissues. Liquefaction is apparently aided by strong salivary juices, and the whole of the interior of the bulb is eventually reduced to a semi-liquid decaying mass. As the larvae become larger they feed less regularly and less voraciously and are not so inclined to break down fresh portions of the bulb, but continue to lie in the decayed areas with their posterior spiracular processes protruding into the nearest air-pocket.

In view of the controversy which has existed regarding the ability or the reverse of these larvae to attack and enter bulbs previously healthy, numerous experiments were conducted in order to demonstrate that such an ability exists. Actual behaviour of the larvae in the field has already been described and some of the experiments carried out will be recounted shortly.

*Pupation.*—As just mentioned, the larvae flourish best in very moist decaying tissues, and provided that these conditions obtain and that the temperature remains low, they will continue as larvae in a semi-dormant condition throughout the winter months. Normally, provided that they are fully fed or that conditions become unfavourable, such as result from the partial drying up of the bulb, or the entire exhaustion of the food supply, and that at the same time the temperature is sufficiently high to permit of it, pupation will take place. Unlike the larvae, the pupae dislike very moist conditions, and therefore migration takes place from the attacked portions. The summer broods, which have fed up rapidly, nearly always pupate in the neck or between the outer scales of the attacked bulb, or even higher up in the dried foliage at surface-level, rarely travelling far from the attacked bulb and not burrowing through

the ground, unless this is of a very sandy nature. Emergence of the adult takes place after about 14 days in the summer months, and the fly has no difficulty in making good its escape, as the hole above the bulb, left by the drying of the foliage is still present. With the over-wintering larvae the case is a little different; the bulb will usually be further decayed, last year's foliage will have entirely disappeared, and at the same time the hole or funnel above the bulb will have become filled in. The larvae therefore leave the bulb and burrow through the soil almost to the surface, where they pupate, often many inches from the remnants of the bulb. As previously pointed out, the larval period is exceedingly elastic as regards duration, this being governed almost entirely by local conditions of temperature, moisture, etc. This can be demonstrated with ease by bringing overwintering larvae into the laboratory during any autumn or winter month. Pupation will take place within a few days. The length of duration of the pupal period is a fairly rigid one, it rarely being less than 14 or more than 21 days, regardless of the time of year at which it is commenced.

### Examination of Samples.

Examinations of numerous samples of narcissus bulbs were made with a view to determining the frequency of attack by these flies, in the presence or absence of other organisms which might have caused primary injury to the bulbs. In all, 193 separate samples were examined, and it must be understood that they were sent in most cases by growers who suspected that there was something wrong with them. This fact accounts for the small number of entirely healthy samples found.

Number of samples entirely healthy	...	...	...	...	24
Number of samples attacked by organisms other than <i>Tylenchus dipsaci</i> or <i>Eumerus</i> spp.	...	...	...	...	36
Number of samples attacked by <i>Tylenchus dipsaci</i>	...	...	...	...	87
Number of samples attacked by <i>Eumerus</i> spp.	...	...	...	...	41

A more detailed analysis of the samples containing the larvae of *Eumerus* was then made as follows:—

Number of samples containing both <i>Tylenchus dipsaci</i> and <i>Eumerus</i>	...	...	...	...	...	...	...	27
Number of samples containing <i>Eumerus</i> spp. alone	...	...	...	...	...	...	...	14

It should be mentioned that the 27 samples containing both *Tylenchus dipsaci* and *Eumerus* spp. frequently contained other organisms such as *Rhizoglyphus spinilarisus*, the bulb mite, but in the 14 samples referred to *Eumerus* alone, 12 contained no other organism at all. The remaining two had a few bulb mites present on some of the bulbs, but these had never penetrated far into the interior, and some bulbs in each sample were entirely free from them. While it is dangerous to draw percentage conclusions from such a small number of samples, it is worthy of note that no less than 24 per cent. of the diseased batches contained *Eumerus* larvae and 8 per cent. *Eumerus* larvae alone.

### Experimental Work.

The foregoing data suggested the desirability of determining whether the female flies showed any great preference for bulbs already attacked by the bulb eelworm (*Tylenchus dipsaci*), as opposed to healthy bulbs, for the purpose of ovipositing.

#### Series 1.

The experiments were conducted in perforated zinc cylinders, 18 inches in height and 8 inches in diameter. The cylinders were placed over growing bulbs, four in each cylinder. Female flies were taken in copula and two were released in each cylinder.

The bulbs were lifted and examined one month after the introduction of the flies.

Cylinder A	...	4 healthy bulbs	...	...	2 attacked
" B	...	4 healthy bulbs	...	...	3 attacked
" C	...	4 healthy bulbs	...	...	0 attacked
" D	...	4 diseased bulbs	...	...	2 attacked
" E	...	4 diseased bulbs	...	...	4 attacked
" F	...	4 diseased bulbs	...	...	3 attacked
" G	...	2 healthy bulbs	...	...	0 attacked
		2 diseased bulbs	...	...	2 attacked
" H	...	2 healthy bulbs	...	...	0 attacked
		2 diseased bulbs	...	...	0 attacked
" I	...	2 healthy bulbs	...	...	0 attacked
		2 diseased bulbs	...	...	2 attacked
" J	...	2 healthy bulbs	...	...	1 attacked
		2 diseased bulbs	...	...	1 attacked
" K	...	2 healthy bulbs	...	...	1 attacked
		2 diseased bulbs	...	...	2 attacked
" L	...	2 healthy bulbs	...	...	0 attacked
		2 diseased bulbs	...	...	0 attacked
TOTALS	...	24 healthy bulbs	...	...	7 attacked
		24 diseased bulbs	...	...	16 attacked

The experiments were carried out in triplicate, and it is sufficient for our purpose to give the totals for the other two series.

*Series 2.*

TOTALS	...	24 healthy bulbs	...	...	4 attacked
		24 diseased bulbs	...	...	9 attacked

*Series 3.*

TOTALS	...	24 healthy bulbs	...	...	8 attacked
		24 diseased bulbs	...	...	16 attacked
TOTALS for the three series :—					
		72 healthy bulbs	...	...	19 attacked
		72 diseased bulbs	...	...	41 attacked

*Series 4.*

A number of experiments were next carried out with newly-emerged and very young larvae, in order to determine the extent to which they were able to penetrate sand and soil in search of food.

Experiment A.—Numbers of healthy bulbs with the tops dried off, except at the actual bulb neck, were buried in damp earth with the necks two inches below the surface level. Eggs were placed directly above the bulbs on the soil surface. The bulbs were examined one week after the eggs hatched.

Result. No larvae found or entered the bulbs.

Expt. B.—As A, but using instead unhealthy bulbs.

Result. As previously.

Expt. C.—As A, but bulbs only one inch below surface-level.

Result. As previously.

Expt. D.—As C, but using unhealthy bulbs.

Result. As previously.

Expt. E.—As A, but necks of bulbs left exposed level with the soil-surface.

Result. Many larvae gained admittance.

Expt. F.—As E, but using unhealthy bulbs.

Result. As in E.



*Series 5.*

Carried out on identical lines with the previous series, but using instead larvae approximately one week old.

Results. Similar to those in series 4.

*Series 6.*

As before, but using larvae approximately two weeks old.

Results. No larvae entered any bulb.

*Series 7.*

As before, but using larvae approximately three weeks old.

Results. Failure to effect entry except in F, in which several larvae entered a badly decayed bulb.

*Series 8.*

A number of experiments were made to demonstrate the ability of young larvae to enter perfectly healthy bulbs under conditions met with in the field. The experiments show, as do the previous ones, that the young larvae can enter healthy bulbs, but apparently not quite so readily as they can those already damaged.

Experiment A.—The foliage of a number of healthy bulbs in pots was allowed to die down normally, and numbers of eggs were then placed in the cavity in the earth in close proximity to the bulbs; 24 bulbs were so treated and examined one week after the eggs had hatched; 10 bulbs contained larvae in the neck and 2 contained them in the vicinity of the basal plate.

Expt. B.—This experiment was the counterpart of A, except that the bulbs used already contained bulb eelworm. Examination showed that 18 of them were entered by the larvae, usually at the neck, as was the case in A.

Expt. C.—The experiment A was again repeated, using this time larvae which were about half-grown. Examination one week later showed the larvae to be congregated around the bases of the bulbs and only in one case had entry been effected.

Expt. D.—As B, using larvae as in C. At the end of a week entry had been made into 3 only of the bulbs and the remainder of the larvae were as before congregated around the bases, but appeared unable to penetrate the outer scales.

*Series 9.*

Previous observations and experiments having pointed to the inability of the larger larvae to enter a bulb, it was decided accurately to record their behaviour when placed near healthy and diseased ones. The practical significance of this lying in the possibility of migration from bulb to bulb in the field, in search of further food supplies.

Experiment A.—Four healthy bulbs were planted in a pot and some 250 three-quarter-grown larvae released over them. Examination one week later showed that the larvae were congregated around the bases, but in no case had a bulb been entered or, so far as could be seen, had any attempt been made to feed.

Expt. B.—Experiment A was repeated with like results.

Expt. C.—A further repetition; results again similar.

Expt. D.—Similar to the above, but the bulbs were placed in a hot-house and not examined for three months. At the end of that period some undersized adults commenced to emerge and examination showed the bulbs to be undamaged.

Expt. E.—Two healthy and two diseased bulbs were potted together and larvae released as previously. The bulbs were examined one week later and larvae were found in the diseased bulbs, the healthy ones being untouched.

Expt. F.—A similar experiment to E. In this case only one of the diseased bulbs had been attacked by a few larvae. The healthy ones were again untouched.

### Discussion of Experiments.

Several very definite conclusions may be drawn from the experiments just described, particularly with reference to the facility with which attack on healthy, as opposed to previously diseased, bulbs can take place. The result of the experiments in Series 1 to 3 is certainly striking. While plainly some considerable preference is shown for bulbs already diseased, at the same time, even when a choice is made available, healthy bulbs are not entirely neglected by the ovipositing females. Great care was taken that the bulbs chosen should be in a condition usually met with in the field at the normal season of oviposition of the flies. There is no doubt that entry into sound bulbs by the larvae can take place under favourable conditions, and that such are constituted by the presence of moist tissue at the point where the foliage is dying away from the neck of the bulb. If the basal portion of the foliage is dried out and the neck of the bulb entirely healed over, such entry seems to be impossible. Some preference for bulbs already damaged is certainly shown by the females when ovipositing, and the practical application of our knowledge of this will be shown a little later.

Experiments in Series 4 to 7 show clearly that young larvae are not able to burrow far through the soil in search of food and that they do not appear capable of finding bulbs at some little distance below soil-level. As with the previous experiments, a practical application of this observation will be suggested shortly. Series 8 shows, as do Series 1 to 3, that given favourable conditions young larvae are capable of entering perfectly healthy bulbs, but that at the same time entry is somewhat more easily effected into bulbs already damaged. The experiments in Series 9 were carried out with the object of demonstrating that larger larvae were not likely to enter any but badly damaged bulbs and therefore that migration from bulb to bulb in the field is unlikely to occur.

The chief facts which emerge from the foregoing may be briefly summarised as follows. Eggs are laid on or near healthy as well as previously diseased bulbs, but where a choice is available the latter are more frequently utilised. Newly-emerged larvae are quite capable of entering bulbs previously sound, under conditions frequently met with in the field, and these bulbs will eventually be destroyed by such attack. These flies must, therefore, be considered as primary pests of the narcissus. At the same time any but very young larvae are not readily able to enter healthy bulbs and therefore migration in the field from bulb to bulb is not found to occur.

### Control Measures.

It is well to realise that no control method, if practised by itself, can be expected to prove 100 per cent. efficient and that even if a grower is able completely to eradicate the pest from his bulb fields, he must remain constantly on the alert. The flies are now so generally established that reinfestation is bound sooner or later to occur, unless preventive methods are carried out as a matter of routine. Control measures may be separated into two divisions, the first comprising remedial treatment for bulbs already infested with the larvae, and the second, preventive treatment of bulbs so far free from injury.

### *Remedial Treatment.*

*Discarding of soft bulbs.*—When planting, all bulbs which feel in the least soft or spongy must be regarded with suspicion and should be discarded and subsequently destroyed. While most growers make a practise of discarding such bulbs, their destruction is frequently not carried out. Instead, the bulbs are thrown into the nearest hedge, or in coastal gardens often cast into the sea. It is obvious that if such bulbs are left in the hedge-bottoms flies will, in due course, emerge and attack the bulbs in adjacent beds. Even the throwing of the bulbs into the sea is not a safe method of disposal. Such bulbs may well be stranded again on the next tide and flies have actually been bred from bulbs collected from such sites. The only safe method of disposal is to burn all bulbs so rejected or alternatively to subject them to one of the methods now to be discussed.

*Hot water treatment.*—The method of control usually adopted for the bulb eelworm, *Tylenchus dipsaci*, consists of the immersion of the bulbs, while in a dormant state, in water heated to a temperature of 110° F. for three hours. This method is too well known and widely practised to merit detailed description here. Such treatment is equally efficient in dealing with bulbs known to harbour or suspected of harbouring fly grubs, in fact it was first used against the large bulb fly, *Merodon equestris*, and later extended to include the destruction of eelworms. No grower is wise to buy bulbs without first obtaining a statement to the effect that the bulbs have been so treated.

*Fumigation.*—A method of fumigating stored tulip bulbs for the control of Aphids has recently been described by Stenton.<sup>4</sup> The fumigant employed was para-dichlorobenzene, and when used by the writer on dormant narcissus bulbs containing fly larvae it was found to be entirely successful. The dosage finally adopted after many trials was similar to that previously used, namely, 4 oz. of para-dichlorobenzene to a cubic foot. It was found that at this strength the duration of fumigation used by Stenton was too short to effect a 100 per cent. kill of the larvae, and so the period was extended somewhat. At the strength advocated above it was possible to obtain a 100 per cent. kill with an exposure lasting 120 hours. Using half the dose, namely, 2 oz. to a cubic foot, an exposure of one week was essential.

The fumigations were carried out in air-tight containers, the bulbs being placed in layers about 4 inches in thickness. The crystals of the fumigant were spread on the bottom of the container and covered with a layer of coarse sacking in order to keep them from actual contact with the bulbs. Reference should be made to the article by Stenton mentioned previously for further details regarding the use of this substance as a control for bulb pests. No damage to treated bulbs was observed at the time of treatment or subsequently, this in spite of the fact that many of the bulbs used were not fully dormant at the time. There seems to be no reason why this method should not be widely adopted in the future as at least a partial substitute for the costly hot water treatment dealt with in the previous paragraph.

### *Preventive Treatment.*

*Ripening under cover.*—It is the practice, when growing commercially, to lift narcissus bulbs at intervals usually of three years, for the purpose of increase. In the case of many varieties the most desirable time for such lifting coincides with the time of oviposition of the bulb flies. Lifted bulbs are very frequently left lying on the surface of the beds for days or even weeks after lifting, in order that they may dry off and ripen. Such bulbs constitute an easy prey for the ovipositing female flies, and as a result growers are frequently heard to complain of increased infestations in beds of such bulbs during the season immediately following replanting. It is in any case a debatable point as to whether or not the drying in hot sunshine may cause



severe injury to the bulbs by scorching. It is therefore suggested that bulbs be carted immediately on lifting and spread to dry under the cover of a shed or lean-to outbuilding. Such cover need not be fly-proof, as it has been observed that the flies will not attempt to oviposit on the bulbs even in the event of all sides of the shed being open.

*Decoy heaps.*—It has been found that the placing of small heaps of worthless and preferably damaged bulbs in the vicinity of the beds will attract numbers of the flies to oviposit on them, in preference to the actual beds. Such heaps may be removed after a short time and destroyed, thus accounting for a number of the fly larvae. It should be remembered that the summer broods of the fly mature in about six weeks and that it is therefore unsafe to leave such a heap of bulbs exposed for a longer period than that, or a danger will be incurred of the flies actually emerging from the heap.

*Deterrent sprays.*—The spraying of some deterrent, such as a miscible oil, on the bulb beds at intervals during the period of maximum oviposition has been tried. Unfortunately no accurate data were collected, but it is certain that this method of prevention is worthy of further testing.

*Raking of beds.*—As clearly demonstrated in the experiments already discussed, the young larvae are not very proficient at burrowing through the soil in search of a bulb, and normally they crawl down the cavity in the ground left by the drying of the foliage. As long ago as 1915, Fryer<sup>2</sup> observed the use which the flies made of these cavities and suggested that filling them in might be of practical value. This measure has proved to give effective control on an experimental scale and has recently been adopted by several growers on a large scale.

The tops of many varieties of narcissus have, at least in the West Country, died down very considerably by the time that oviposition becomes at all general. As a normal cultural procedure the beds are eventually raked over and cleaned, in the course of the process the dried foliage being dragged off and the holes above the bulbs being filled with earth. In the event of this raking being carried out towards the latter end of May, instead of in June and July as is more usual, the flies will tend to go elsewhere for the purpose of ovipositing, and even if eggs are laid, it is unlikely that many of the larvae would be able to locate the bulbs. Critical observation of such an experiment when conducted on a field scale is naturally somewhat difficult, but it is significant that there were but few signs of oviposition in treated areas and that bulbs lifted in the autumn from beds so raked had a considerably lower percentage of attacked bulbs than was usual.

Certain varieties of narcissus do not lose their foliage in time for treating as suggested and these require somewhat different treatment. If they are yellowing, the best plan appears to be to cut the foliage off short and to earth up the rows, taking care that the cut ends are actually buried. If on the other hand they are still vigorous, they are probably best left alone, as the flies do not appear to be attracted to such plants, the reason for this probably being that there is no very suitable starting-off point for the larvae while the foliage is still vigorous. At the same time such a bed would lend itself readily to spraying, as previously suggested, with a suitable deterrent.

It is certain that the best way in which to keep a continual check on attacks by the flies is to make conditions in the field as unsuitable as possible for oviposition, and for the subsequent penetration of the larvae to the bulbs themselves. Having due regard for all available data this appears to be a by no means impossible task, and at the same time one which would become increasingly easy as more growers in any given area undertook such methods, thereby reducing the acreage of potential breeding-grounds.



**Acknowledgements.**

In conclusion, the writer would like to express his appreciation of the kind advice and assistance afforded by Mr. J. C. F. Fryer, of the Ministry of Agriculture, and his thanks to Mr. J. E. Collin for identifying some of the specimens.

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Fig. 1. *Eumerus tuberculatus*, Rond., ♀, × 11.



Fig. 2. *Eumerus tuberculatus*, Rond., ♂, × 11.





Fig. 1. Section through bulb showing larvæ of *Eumerus tuberculatus* in situ.

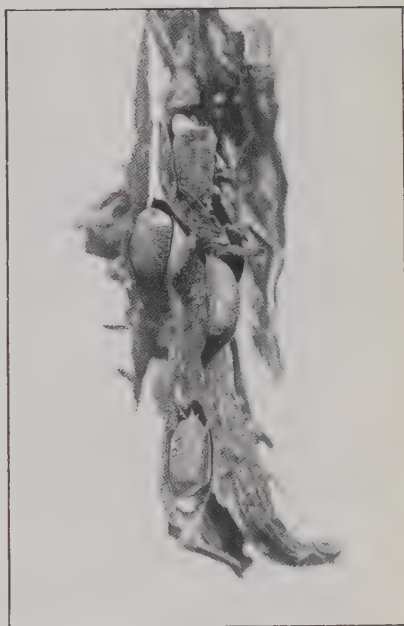


Fig. 2. Pupæ of *E. tuberculatus* on dried foliage.

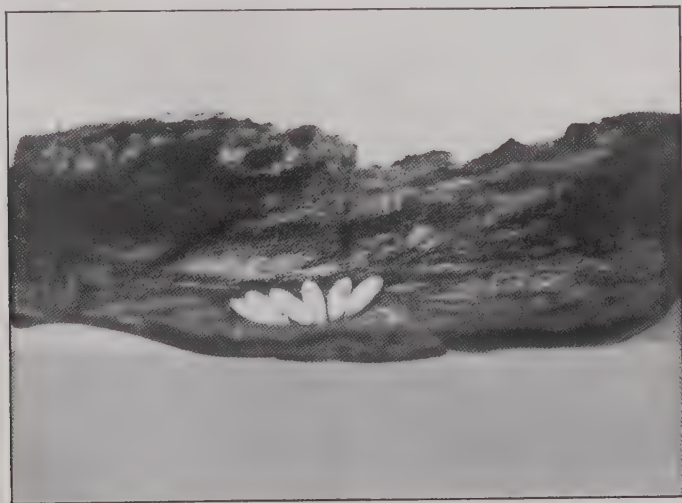


Fig. 3. Eggs of *E. tuberculatus* on dried foliage.





# THE INTRODUCTION OF *CRYPTOLAEMUS MONTROUZIERI*, MULS., INTO EGYPT. <sup>W.</sup>

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(PLATES XXXIII—XXXIV.)

## Introduction.

The activities of the Australian Ladybird beetle, *Cryptolaemus montrouzieri*, Muls., are too well known to need recapitulation. It is sufficient to say that it has been introduced into many countries with a greater or lesser degree of success, generally for the control of "mealy-bugs."

The introduction of this beneficial insect into Egypt may present certain features of interest to other workers in spite of the fact that there is a great deal yet to be done. Series of experiments have been designed to elucidate certain points, but owing to the departure of the writer from Egypt these have been left to others to carry out. A detailed account of this work had been planned for a later date, but in the circumstances it may be as well to place on record what has been done up to the present time.

Some five or six years ago sugar-cane in Egypt suffered very severely from the ravages of the sugar-cane mealy-bug, *Pseudococcus sacchari*, Ckll. This pest was responsible for heavy financial losses, and control measures were urgently called for. The problem was studied by the writer and a Bulletin\* was published giving a full account of the outbreak and recommending certain control measures. At the same time, in view of the fact that it was known that *Cryptolaemus montrouzieri* had been introduced and proved itself an effective natural control of this same pest elsewhere, arrangements were made to introduce a consignment into Egypt.

Mr. E. W. Adair, Entomologist, formerly of the Ministry of Agriculture, was spending his leave in the South of France in the early summer of 1922, and was requested by the Ministry to bring back a consignment with him from Menton. Owing to the unusually severe climate conditions at Menton early in the year the *Cryptolaemus* were scarce, and Mr. Adair was able to secure only four adults and three pupae. By the time he arrived at Alexandria, on the 5th August, 1922, he had six adults, two of the pupae having emerged. The third pupa was parasitized by a Chalcid and died *en route*.

These six adults were put into a cage on arrival at Cairo and fed on the citrus mealy-bug (*Pseudococcus citri*, Risso). Later, when the colony began to increase, a diet of lebbek mealy-bug (*Pseud. filamentosus*, Ckll.) and hibiscus mealy-bug (*Phenacoccus hirsutus*, Green) was tried with success.

A consignment received from California, in October 1922, failed to survive the journey, and no living *Cryptolaemus* in any stage was found on arrival.

## *Cryptolaemus* and Sugar-cane Mealy-bug.

Sugar-cane in Egypt is planted from the end of February to the beginning of June and harvested from the beginning of January to the end of April. The attacks of the mealy-bug do not become apparent until about November, after which they increase rapidly in intensity.

Nag Hamadi, the centre of one of the largest sugar-growing areas in Upper Egypt, was chosen as being the most suitable locality in which to breed the *Cryptolaemus*

\* "The Outbreak of *Pseudococcus sacchari* Ckll. on the Sugar Cane of Egypt," Min. Agric. Egypt Bull. no. 26 (1922).

and attempt to establish it in the field. For this purpose 20 beetles were transported from Cairo on the 25th November 1922, and this colony was further strengthened by an additional 20 on the 22nd December.

Conditions in the cages were made as favourable as possible. Short lengths of heavily infested cane, from which the leaf-sheaths had been removed so as to give the beetles ready access to the mealy-bug, were supplied. The larvae fed on all stages of the mealy-bug, and the adult beetles also fed to a limited extent (Pl. xxxiii, fig. 1). It was found that the night temperatures were so low as to affect the development of the beetles adversely, and artificial heating was introduced, ensuring a more or less constant day and night temperature. Under these conditions the *Cryptolaemus* went ahead well, and by February the cages had been increased to 30.

It has already been pointed out that the harvesting of the cane begins in January and practically all the cane has been cut by the end of April. Arrangements were therefore made with the Sugar Company to leave 4 plots, each of 2 kerats, standing, on which the *Cryptolaemus* could be released, and 1 kerat of heavily infested cane to provide food for the Insectary. The plots selected were in the middle of large fields of first year cane. The cane on the land surrounding the plots was all cut in due course, and it was hoped that, if colonies of the beetle were liberated in the small plots left standing, they would breed and multiply, subsequently spreading on to the second year cane as it grew up.

On these 4 plots 521 adults were liberated during February, but it very soon became apparent that the experiment was to be a failure. The cane grown at Nag Hamadi is almost exclusively destined for sugar extraction at the factory, and the variety of cane which has been found to be most satisfactory for this purpose is that known locally as "Java 105." One of the characteristics of this variety is that the leaf-sheaths are very closely adherent to the parent cane. The mealy-bug is found clustered just beneath the node and sheltered by the leaf-sheath arising from the node next below. So sheltered is it that the *Cryptolaemus* is unable to penetrate to it in the field until the cane is practically fully grown, when the leaf-sheaths come away slightly, but by that time the mealy-bug has done its damage.

Further colonies were planted out on the 5th May, owing to the difficulty of obtaining sufficient food for those in the Insectary.

The main reason for the failure of the *Cryptolaemus* has already been given, but there are other reasons that would militate against its success in the field.

1. The sugar-cane mealy-bug does its damage to the crop during the winter months. The cold nights during this period seriously retard the development of the *Cryptolaemus*, so that whilst the conditions are apparently favourable for the rapid multiplication of the mealy-bug, they have an adverse effect on the *Cryptolaemus*.

2. It has been found in Egypt that even under the most favourable conditions in the Insectary a heavy mortality occurs between February and April.

3. During the summer months when the conditions are favourable to the *Cryptolaemus* the cane is young and the attack of the mealy-bug slight.

The experiment at Nag Hamadi was brought to an abrupt close owing to the food shortage, as a result of which the *Cryptolaemus* turn cannibalistic. The plot of cane left standing for food died through lack of water, and owing to a misunderstanding three of the four plots on which the beetle had been released were cut. By this time, however, we were convinced of the futility of carrying on the experiment, and 18 adults were transferred back to Cairo on the 29th May 1923, the remainder being left at Nag Hamadi at the disposal of the Sugar Company.

A small colony had been left in Cairo, but this died out during the early months of the year, possibly owing to the difficulty of arranging for artificial heating and sufficient moisture.

### **Cryptolaemus and Hibiscus Mealy-bug.**

When it was found that the *Cryptolaemus* was of no avail in the control of the sugar-cane mealy-bug, it was decided to attempt to establish it as a natural enemy of the hibiscus mealy-bug, which was giving us a considerable amount of trouble at the time. An account of this pest and the control measures recommended will be found in two Bulletins by the writer.\* It is, therefore, unnecessary to go into the details of the outbreak here. The pest has since spread practically all over Egypt, and attacks chiefly certain permanent ornamental and shade trees.

The new Insectary was completed early in 1925, and consists of one inner room and an office surrounded on three sides by a wide balcony. On one side a portion of this balcony has since been netted in, giving an additional room. The insects are bred in small cages of the usual type, 11 in. by 11 in. by 18 in. (excluding the legs), fresh food being supplied every other day.

About once a month every cage is cleaned ; this is necessary to prevent the cages from getting too full. Care has to be exercised in this operation owing to the delicate nature of the larvae, which are found amongst the top layers of fresh and comparatively fresh food, whilst the pupae occur in the lower strata of dried and semi-dried material. This latter is carefully removed from the cages, and a pile of it is made under one of the tables on which the breeding cages rest. Many beetles subsequently emerge from this material. When the cages are next cleaned out this old material is removed from the Insectary to a small breeding shed outside to make room for the new lot of material. After the material is moved to the shed it contains very few *Cryptolaemus* in any stage, and this material is turned out and burnt to make room for the next consignment in due course. The number of cages has been so increased this year (1926) that both the inner and the balcony rooms are full and an overflow of 50 cages is housed in the office. The beetles are collected daily in glass tubes for liberation in the field. The quickest method is to open the doors of the cages allowing them to escape into the room. The white walls and ceiling of the inner room render the beetles conspicuous and they can be easily caught.

During the winter months the inner room only is utilised, and by means of an electric heater the temperature is kept more or less constant between 24° C. and 28° C. This range of temperature appears most favourable to the insect, but further investigation on this point is required.

After December it becomes extremely difficult to find material sufficiently heavily infested with hibiscus mealy-bug, and the diet is changed to one of sugar-cane mealy-bug. It is not, however, possible to obtain infested sugar-cane after about the middle of April, and the hibiscus mealy-bug does not start making its presence felt until the beginning of June. Consequently the month of May is a critical one, and the difficulty of procuring sufficient food for the Insectary may become acute. This factor must be seriously considered if the scope of the work is to be enlarged. It may even be necessary to ensure heavy infestation of a number of plants by artificial means. This should not be difficult.

It has been found, particularly in the winter, that it is necessary to keep the floor of the Insectary damp. The question of the degree of humidity most favourable to the *Cryptolaemus* is one that requires investigation ; it might possibly be found to have some bearing on the retarded activity in the Insectary during the earlier months of the year. It has often been noticed that in cages where no *Cryptolaemus* were apparent a little water sprinkled on the floor of the Insectary would bring out

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\* "The Hibiscus Mealy Bug," Min. Agric. Egypt Bull. no. 17 (1921). "The Hibiscus Mealy Bug (*Phenacoccus hirsutus*, Green) in Egypt in 1925, with notes on the Introduction of *Cryptolaemus montrouzieri*, Muls.," Min. Agric. Egypt Bull. no. 70 (1926).



the adults in the cages and make them assume, temporarily at least, some signs of activity. It may also be pointed out that the *Cryptolaemus* is most active from August to October, the three most humid months of the year.

### Life-history and Habits of *Cryptolaemus*.

The length of the life-cycle varies according to the time of year and is affected by the conditions under which the insect finds itself.

Eighteen beetles which were transferred to Cairo from Nag Hamadi (Upper Egypt), on the 29th May 1923, produced a new generation of adults on the 21st June, so that in this case the total length of the life-cycle was 23 days. This was under the favourable conditions pertaining in the Insectary. During the summer months in the Insectary the life-cycle varies from 3 to 5 weeks. The egg hatches in from 3 to 5 days, and the larva takes from 2 to 3 weeks before becoming fully fed and pupating. The pupal stage lasts from 6 to 9 days.

A pair of adults taken in copulation on the 20th June were put into a box by Mitwalli Eff. Guindi and watched at home. The larvae were isolated as they hatched out, and carried through separately. The conditions were probably not quite so favourable as in the Insectary. In this case the egg stage lasted 6 days, the larval stage from 20 to 23 days, and the pupal stage from 10 to 12 days, the life-cycle taking in all from 36 to 42 days. From direct observation in the field it appears that the life-cycle under favourable conditions is usually between 4 and 5 weeks. In captivity the life-cycle may vary from 23 to 42 days at approximately the same time of the year.

In spite of the fact that the conditions are made as favourable as possible during the winter months in the Insectary, from the beginning of January development is much retarded and mortality sets in. The colony steadily gets less in spite of abundant food until the beginning of May, when there is a recrudescence of activity amongst the survivors and the colony again forges ahead. Further work is necessary to elucidate the reasons for this falling away, and breeding under different temperatures and different degrees of humidity should be undertaken.

It is said in some countries that the *Cryptolaemus* is lazy and that even if it is established in one locality it will not greatly enlarge its sphere of activity. There is evidence that this is true for Egypt. It is obvious that this is a drawback, but it is a drawback that would have to be faced in Egypt in any case. The hibiscus mealy-bug, generally speaking, is a pest of certain permanent trees and shrubs, which in Egypt are practically confined to the villages and towns, very few being found in the field—in the Delta at least—which from this aspect presents a barren outlook. The activities of this mealy-bug are consequently confined to the towns and villages, and it does not seem likely from the experience of other workers and our own that even if the *Cryptolaemus* were established in a town it would spread to another town, say, 10 miles away, if the intervening area was devoid of food. There are, of course, other species of mealy-bugs that attack crops and plants found out in the field, but they require looking for, and it seems unlikely that the *Cryptolaemus* would leave the rich feeding ground of the town to explore the poor belt outside. It follows, therefore, that the beetle will have to be established separately in every town or village where the damage is such as to justify such measures. This is neither impossible, nor such a difficult proposition as it would appear, for the number of towns in Egypt where colonization would be justified is not very great.

At the moment the only mealy-bug of any serious import is the hibiscus species, and this can hardly be called a pest of major importance, because it does no damage to field crops. It has been regarded as more serious than it really is, because in ruining the public gardens, nursery gardens, and shade trees of our towns it has been prominently before the public eye (Plate xxxiii, fig. 3).

The artificial measures that have been undertaken to control this pest have met with no small degree of success, and should the *Cryptolaemus* become fully established there seems no reason to doubt that the activities of the hibiscus mealy-bug will cease to cause trouble.

There can be no question as to the efficiency of the *Cryptolaemus* if present in sufficient numbers. That magnificent shade tree, *Albizzia lebbek*, is unfortunately one of those trees most favoured by the hibiscus mealy-bug. Large trees of this species on which colonies of *Cryptolaemus* have been liberated have shown a marked decrease in the degree of infestation. A heavily infested lebbek at Kubbeh in 1923 was kept under careful observation, and so successful was the *Cryptolaemus* that it was difficult to find any mealy-bugs on the tree towards the end of the year.

Two heavily infested hibiscus shrubs at Mataria, in 1923, were enclosed in a mosquito-netting frame and 25 beetles released on them. At the end of two months the shrubs were to all intents and purposes clean.

Perhaps the most interesting and instructive case was provided by two mulberries in pots in the garden of the Insectary. The mulberries in question were bushy shrubs, one being about 120 cm. high and the other 190 cm.

Up to the end of May 1926 the shrubs showed no signs of infestation, and the shoots were strong and healthy. On the 13th June a piece of heavily infested lebbek was put on each shrub, and a week later the shrubs were heavily infested, every terminal shoot being gnarled into a compact head. An adult *Cryptolaemus* was observed on the smaller of the two shrubs on the 17th June, and four days later three beetles were found on each shrub. These had undoubtedly escaped from the Insectary and found their way to the infested shrubs.

Ten adult beetles were liberated on each shrub on the 22nd June, and on the 5th July the first larvae were noticed. By the 10th July there were large numbers of larvae, and in a very short time the *Cryptolaemus* gained complete mastery. New shoots began to grow out from the gnarled heads on the 22nd July, and these became fine healthy shoots with nice clean growing points, and they were still in that condition when I left Egypt about the middle of September (Plate xxxiv). The shrubs had been given a new lease of life.

The action of the hibiscus mealy-bug in causing gnarling of the terminal shoots is characteristic, and had it been left to itself the pest would have continued to work its ravages until November, completely arresting growth and weakening the vitality of the shrubs. Such a tree would not have shown any fresh growth until the following spring, and as soon as it had begun to put forth its new shoots the mealy-bug would have resumed its activities, and gnarling and arrested growth would have again ensued. That the *Cryptolaemus* should have been able to gain such a mastery over the mealy-bug as to allow the shrubs to put out new and clean growths in the middle of the summer is a testimonial to its efficiency. It is also very effective against the sugarcane mealy-bug when it can reach it, but for reasons which have already been given it proved a failure in the field.

It was thought at one time that ants might combat the good work of the *Cryptolaemus*. It may be stated here that though the hibiscus mealy-bug is often attended by ants, this is by no means an invariable rule, and heavily infested trees have been observed without any ants going up or down the bole. In the case of the experiment on the mulberries detailed above, no attempt was made to encourage or discourage ants. A large and a small species of ant were invariably present on both shrubs in moderately large numbers. These were carefully watched, but in no case were they observed to interfere with the *Cryptolaemus*. The results, also, proved that at least these two particular species of ants do not hinder the beetle from gaining ascendancy over the mealy-bug.

### Field Operations.

The colony retrieved from Nag Hamadi at the end of May 1923 was, on arrival at Cairo, at once put on a diet of hibiscus mealy-bug. So rapidly did they multiply that by the end of September the number of cages had been increased to 42 and the number of adults liberated was 4,800.

The number of adults liberated in the past four years is shown in Tables I. and II.

TABLE I.

Showing the numbers of *Cryptolaemus montrouzieri*, Muls., released each month during the three years 1923-1925.

	1923.	1924.	1925.
August ... ..	—	1,750	10,000
September ... ..	400	1,050	13,500
October ... ..	600	10,200	8,500
November ... ..	1,800	8,500	8,000
December ... ..	2,000	6,000	3,000
January ... ..	—	11,200	500
Total ... ..	4,800	38,700	43,500

TABLE II.

Showing the numbers of *C. montrouzieri* released every ten days during 1926.

10th July ... ..	2,250
20th July ... ..	6,750
30th July ... ..	6,000
9th August ... ..	6,250
19th August ... ..	3,250
29th August ... ..	250
8th September ... ..	8,750
18th September ... ..	8,250
28th September ... ..	8,750
8th October ... ..	10,500
18th October ... ..	13,000
28th October ... ..	15,000
7th November ... ..	12,500
17th November ... ..	16,000
27th November ... ..	12,500
7th December ... ..	4,800
Total ... ..	134,800

It will be noticed that in 1926 there was a big fall in the number of beetles available for liberation during the latter half of August. This was probably due to the fact that the majority of larvae from the previous generation of adults were pupating. It would have been possible to collect a hundred or two adults a day, but it was deemed advisable to leave these in the cages and cease liberations until the numbers increased. At the very end of August the numbers began to increase again, and liberations were resumed. It will be noticed also that the greatest number available for liberation occurred in October—a damp month. Some exceptionally cold weather set in after the 3rd December 1926, which curtailed the activities of the *Cryptolaemus*, and it was decided not to liberate any more until next year. In the case of mild Decembers, such as were experienced in 1924 and 1925, liberations were continued up to the end of the year.

Lack of accommodation has been the limiting factor in the extension of operations. This year (1926) greater accommodation has been available and the number of cages



has been much increased. The largest number of cages in use during 1923 was 42, in 1924 this increased to 170, but dropped to 120 in 1925. This year (1926) from 112 in April the number has been increased to 375.

The number of beetles liberated this year is nearly three times that of last year, but this is not nearly enough. Assuming that the climatic conditions in Egypt are favourable for the *Cryptolaemus* to establish itself in the field, and there seems no reason to believe otherwise, the problem resolves itself into ensuring a sufficient concentration in any one locality.

The policy adopted in the liberation of the beetles was to select a few localities heavily infested with the mealy-bug for this purpose. In most case the infested plants were *Albizzia lebbek*, a tree attaining large proportions, and the beetles were liberated so far as possible on the same trees each time, in order to get a high local concentration.

The colonies in all cases were kept under careful observation, and it was noticed that the beetles settled down at once and bred rapidly. Towards the end of November activity began to abate, but it was not until the end of January that they apparently disappeared. The habits of the *Cryptolaemus* in the field and in the Insectary appear to be the same in this respect, despite the widely different conditions.

In the spring and early summer of 1924, 1925 and 1926, careful searches were made in the localities where liberations had been effected the previous year. No trace of any *Cryptolaemus* was found in either 1924 or 1925. This does not necessarily mean that there were no survivors, but no definite proof of the survival of a colony through the winter was obtained. Until such proof was forthcoming there was no evidence that any one colony had established itself.

This year, however, it was decided to select new localities for liberation, so that those in which liberations had been made in 1923, 1924 and 1925, could be kept under observation throughout the summer, and if any colony had, perchance, struggled through the winter the summer months would give it an opportunity of increasing and manifesting its presence.

This procedure has provided the first definite proof of success. On the 9th August an assistant was collecting infested material for food for the Insectary at Kubba Gardens when he observed 7 adults on a lebbek tree. Six more were seen in the same vicinity on the two days following. Over 7,000 beetles were liberated here in 1925, but none had been released within 10 miles of it in 1926. It seems legitimate to consider these 13 adults as descendants of the 1925 colony, which must have established itself sufficiently to survive the winter. Further liberations are now being made in the same locality in an endeavour to strengthen the colony and enable it to enlarge its sphere of activity.

No trace of *Cryptolaemus* has yet been found at Ismailia, Mataria or Kena, where colonies were also liberated last year. There is a marked reduction in the degree of infestation of the trees in these localities, but how far this can be attributed to the action of the *Cryptolaemus* it is hardly safe to say. A few larvae have been seen in the Zoological Gardens, but as these are adjacent to the Insectary it is open to question whether these are survivors from last year's colony. Many adults escape from the Insectary and can be found on plants in the immediate vicinity.

The fact that one colony has survived a winter indicates that there is every reason to hope that the *Cryptolaemus* may be established in the field on a large scale. Steps have been taken to increase the numbers liberated this year, but increase, accommodation is essential if operations are to be undertaken on a larger scale. If more highly concentrated colonies can be formed in the field I see no reason why the *Cryptolaemus* should not become established in all the localities that are heavily infested with the hibiscus mealy-bug.



Finally I should like to point out that whatever success is obtained will be largely due to the earlier efforts of Mr. W. E. Adair, Senior Entomologist, late of the Ministry of Agriculture, and Abdel Magid Eff. Mistekawi, Junior Entomologist. I am indebted to Mistekawi Eff. for supplying me with the detailed particulars of liberations since I left Egypt in September. My thanks are also due to my assistant Mitwalli Eff. Guindi, and to all those members of the staff who have assisted at various times. I am indebted to Abdel Fattah Eff. for the excellent photographs here reproduced.

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Fig. 1. *Cryptolæmus* feeding on sugar-cane mealy-bugs.



Fig. 2. *Cryptolæmus* feeding on hibiscus mealy-bugs.



Fig. 3. Two hibiscus plants, one infested with hibiscus mealy-bug and the other clean.





Fig. 1. A mulberry shoot infested by hibiscus mealy-bug.



Fig. 2. An infested mulberry shoot that has put out clean new growth after the mealy-bugs were destroyed by *Cryptolæmus*.





TWO NEW SCELIONID PARASITES OF *LOCUSTA MIGRATORIA*, L.,  
FROM RUSSIA. W.

By A. A. OGLOBLIN.

This summer I received for identification from the Entomological Department of the Experimental Station at Poltava one vial with 12 specimens (2 ♂♂, 10 ♀♀) of a new species of *Scelio* bred from eggs of *Locusta migratoria* ph. *danica*, collected by F. Lukjanovich, 12.viii.1925, at Priluky, Poltava province; and later on Mr. B. P. Uvarov sent me two females of another species from Turkestan. All the representatives of the cosmopolitan genus *Scelio*, Latr., so far as we know, are egg-parasites of ACRIDIDAE. Some species have been bred from *L. danica* in Australia, but in Europe this is the first species of which the host has been recorded. Dr. J. J. Kieffer, in a posthumous monograph of the SCELIONIDAE (Das Tierreich, Lief. 48, 1926), among other generic characters mentioned the four-jointed maxillary palpi. He further distinguished the Australian genus *Neoscelio*, Dodd, from *Scelio* by its having three-jointed maxillary palpi, besides the long metathoracic spine. Unfortunately Kieffer did not mention to which species of the genus *Scelio* his observation referred. I have dissected a few specimens of three species, *S. vulgaris*, Kieff., *S. uvarovi*, sp. n., and *S. nikolskyi*, sp. n., and can state that in both sexes of all these species the maxillary palpi are only three-jointed. The generic definition of the genus *Scelio* must therefore be corrected in this sense.

Many new characters useful for distinguishing the different species of *Scelio* were found in the course of the present work, and since many of them are related to secondary sexual characters, the author is convinced that in future analytic keys for the determination of males and females should always be kept separate.

***Scelio uvarovi*, sp. n.**

♀. Length of body 4.67–4.77 mm.

Black; antennae, mandibles (except the red teeth), palpi, tegulae, all the femora in the middle, and the claws, dark brown; tibiae, tarsi and tips of four hind coxae, reddish yellow.

*Head* (fig. 1a).—Length 0.73 mm., breadth 1.04 mm. Eyes with the short and long diameters as 2:3; the short diameter 0.28 mm., equal to the length of the cheek. Ocelli in an obtuse-angled triangle; the diameter of the front ocellus  $79\mu$ ; lateral ocellus elliptical (7:5), its distance from the orbits equal to the length of its larger diameter (0.079 mm.). Temple broader than the short eye-diameter. Occiput deeply emarginate posteriorly, at the middle not defined from the vertex, distinctly margined latero-ventrally. Forehead broadened towards the toruli (0.825 mm.); narrowest at the line that passes immediately under front ocellus (0.598 mm.); at the vertex, 0.735 mm. Under the front ocellus there is a sharp spine directed into the head cavity. The frontal process dividing the toruli slightly curved, distally with four short terminal hairs and four stronger bristles on each side. Toruli with swollen external margin.

*Antennae* (fig. 2a).—Radicula slightly bent, swollen basally and here covered with very short spines; length 0.09 mm. Scape (5:1) as long as the six following joints together, gradually dilated distally, shagreened cellulate, covered with sparse hairs nearly one-third as long as the breadth of the scape. Second joint distally with two small, round orifices, probably leading to the Johnston's organ usually placed in this

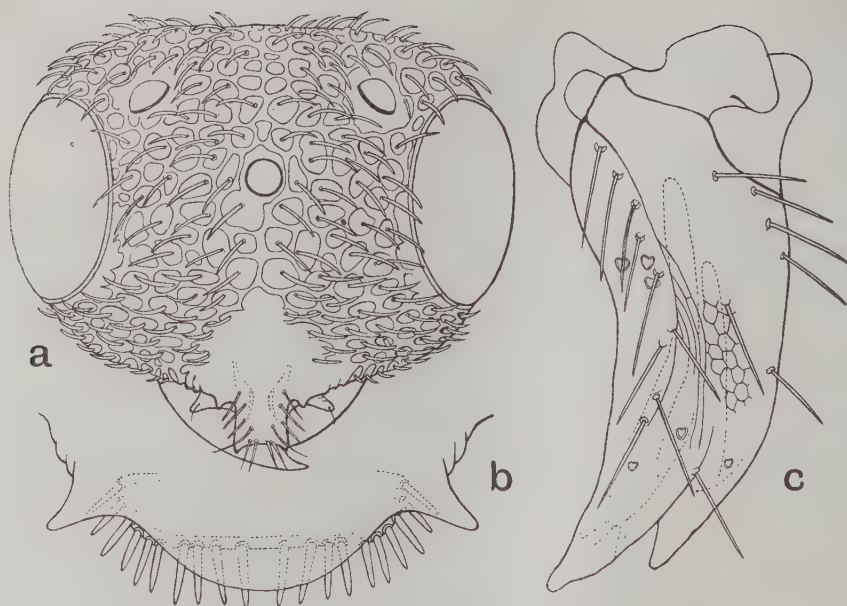


Fig. 1. *Scelio uwarovi*, sp. n., ♀: a, head; b, labrum; c, mandible.

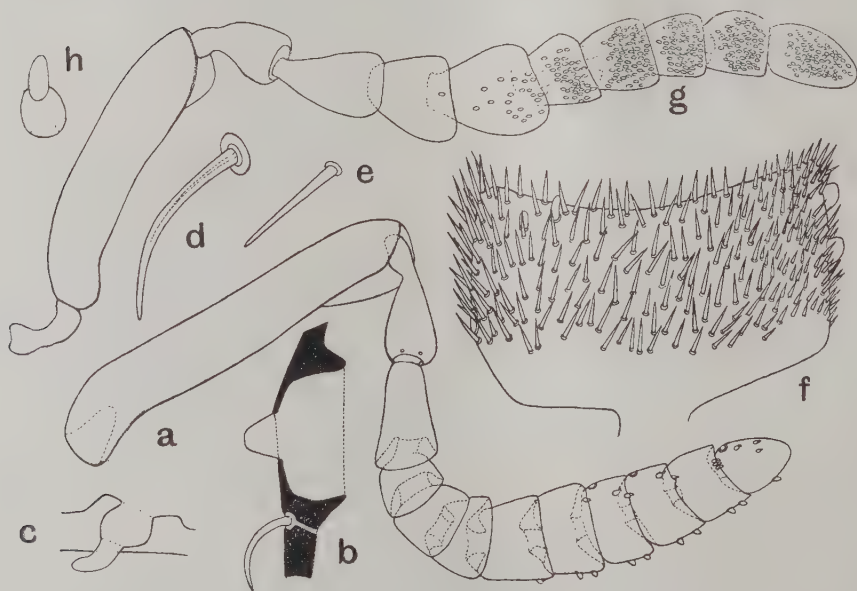


Fig. 2. *Scelio uwarovi*, sp. n. Female: a, antenna; b, c, sensoria; d, tactile hair; e, covering hair; f, eleventh antennal joint. Male: g, antenna; h, sensorium.

joint. Third joint nearly twice as long as distally broad (95:50). The length and breadth of antennal joints respectively as follows:—

0.667; 0.178; 0.161; 0.088; 0.080; 0.080; 0.096; 0.085; 0.085; 0.085;  
0.093; 0.107 mm.  
0.110; 0.076; 0.085; 0.096; 0.112; 0.119; 0.127; 0.127; 0.127; 0.122;  
0.109; 0.085 mm.

The 7th–12th antennal joints ventrally bear bottle-shaped sensoria (fig. 2, *b*), the 12th and 7th having one each, the 8th–11th two. These ventral sensoria, arranged in a row, are very characteristic for the female antennae of all SCELIONIDAE. The 9th–12th antennal joints each dorsally with a single circular sensorium (fig. 2, *a*). External dorsal surface of 8th–12th with sparse sensoria of a third kind (fig. 2, *c*). Joints of flagellum and of club densely covered with fine short hairs; on the joints of the club the hairs are shorter ventrally. Besides the covering hairs (fig. 2, *e*) each joint bears a few tactile hairs (fig. 2, *d*).

*Mouth-parts*.—Clypeus semicircular at the middle, on both sides with a large blunt tooth. Labrum with straight anterior margin, laterally rounded, with 20 stout bristles (fig. 1, *b*). Mandible more than twice as long as broad (0.4 by 0.176 mm.),

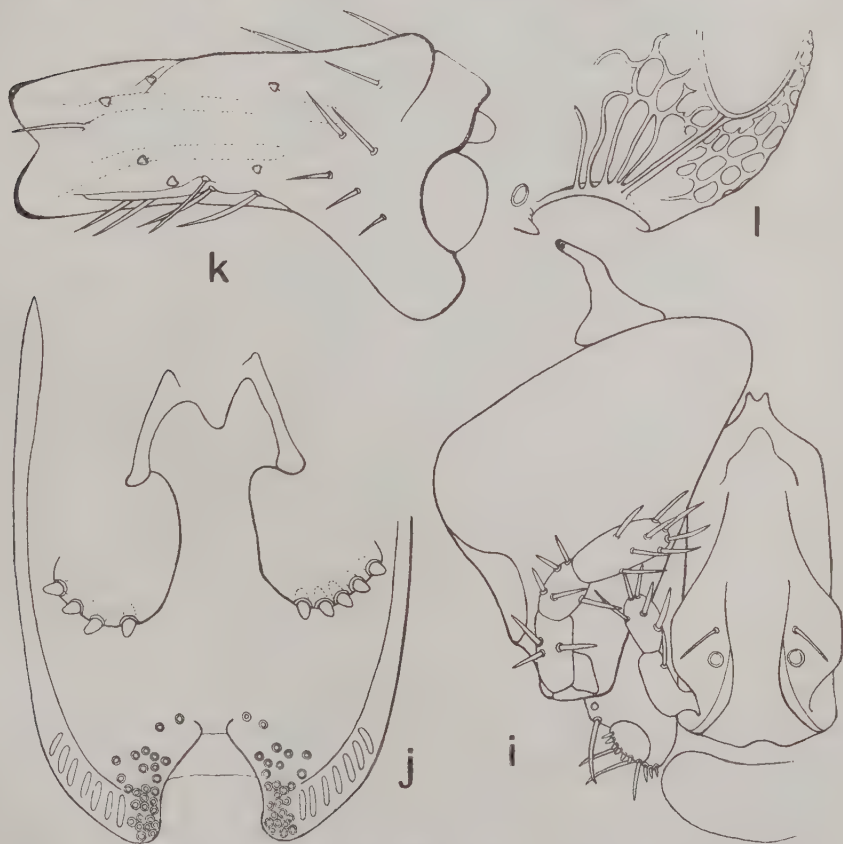


Fig. 3. *Scelio uvarovi*, sp. n.: *i*, first maxilla and second maxilla from below; *j*, tip of male genitalia; *k*, mandible of ♂; *l*, cheek.  $\mu$  — 0.1 mm.



moderately bent, externally with nearly 16 sparse, long bristles and six sensorial pustules; apical teeth pointed. (Fig. 1, *c* shows the mandible a little from above.) Maxilla I with cardo, 25 : 20; stipes, 78 : 45; galea and lacinia very soft, membranous, the former with a round ventral plate bearing 6 long and 8 short bristles. Palpus with three joints ( $68\mu$ ,  $34\mu$  and  $61\mu$ ) of equal breadth ( $27\mu$ ). Maxilla II (labium + glossa), length, 0.270; breadth, 0.109 mm. First joint of palpus  $1\frac{1}{2}$  times as long as the second; length,  $57\mu$  and  $34\mu$ ; breadth,  $20\mu$  and  $19\mu$  (fig. 3).

The general surface of the head with raised reticulation and large punctures, smaller towards the occiput and cheek, each puncture with a thick bent white hair (fig. 1, *a*).

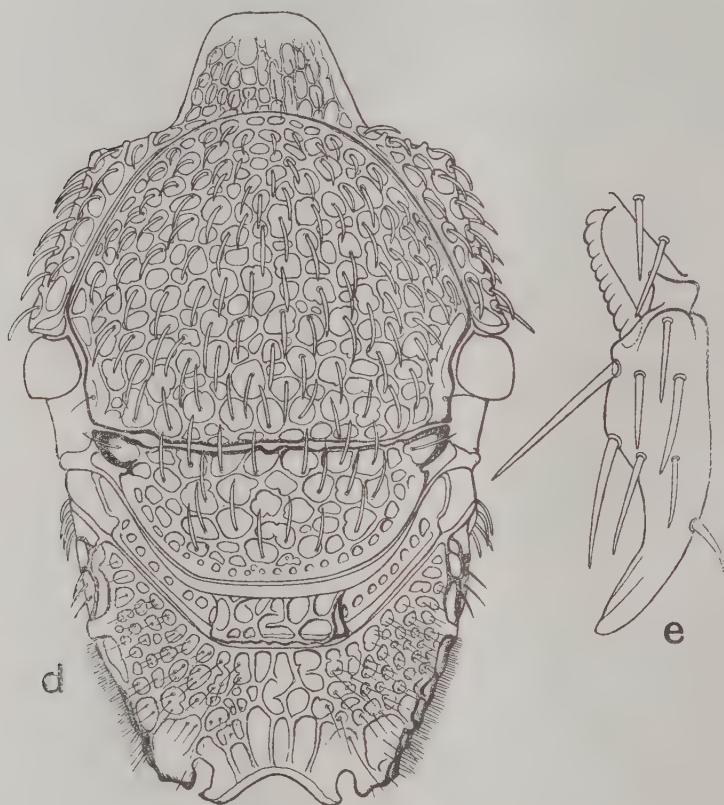


Fig. 4. *Scelio uvarovi*, sp. n., ♀: *d*, thorax; *e*, claw.

The forehead round the bases of the antennae and a narrow space round each ocellus smooth, shining. Cheek with a sulcus genalis; between sulcus and frontal process 5–6 longitudinal keels, confluent above with the raised margins of the punctures (fig. 3, *l*).

*Thorax* (fig. 4, *d*).—Length 1.678 mm., breadth 0.95 mm. Pronotum deeply sinuate posteriorly, as long as the mesoscutum; an indistinct longitudinal keel on the projecting shoulder separates the notal part from the pleural. Spiracles circular ( $34\mu$ );

proepimeral one not distinctly defined, longitudinally striated. Proepisterna smooth and shining in the anterior half, reticulate-rugulose posteriorly, with a thin erect hair in each mesh; the diameter of the meshes decreases caudally and externally. Mesoscutum (0.678 by 0.791 mm.) like the lateral parts of the pronotum and scutellum, nearly evenly raised-reticulate with large punctures; the thick hairs arising from these punctures in front of an imaginary line between the tegulae are directed caudally and behind this line in the opposite direction; the lateral margin of the mesoscutum near the tegula twice shallowly sinuate. Scutellum (length 0.282 mm., breadth 0.706 mm.)  $2\frac{1}{2}$  times as broad as long, with produced antero-lateral angles, separated from the metanotum by a row of deep punctures followed by a smooth space. Mesosternopleurae throughout raised-reticulate with large meshes (under the wing base  $34-57\mu$ ), beyond which after a small round groove with small meshes ( $12-24\mu$ ); sternal surface with meshes of unequal size ( $11-80\mu$ ). Metanotum (length 0.339 mm., breadth 0.678 mm.) with the length at the middle 0.068 mm., medially raised and coarsely rugulose. Metapleurae evenly raised reticulate.

*Propodeon* elongate; max. length, 0.62 mm., length at the middle, 0.309 mm.; breadth between the spiracles, 0.79 mm. Beyond the spiracles slightly constricted; postero-lateral angles produced into large blunt teeth. The dorsal surface unevenly and weakly rugulose-punctate, with fine sparse pilosity. Lateral surfaces from the spiracles to the posterior teeth densely covered with fine silvery hairs. The spiracle elliptical (1:2), raised laterally.

*Wings*.—Forewing (3:1, length 2.921 mm., breadth 0.95 mm.) reaches the base of fifth abdominal tergite. The submarginal vein not reaching the anterior margin of wing; stigmal vein surrounded by brown nebulosity and traceable to the apex, 0.071 mm. long, equal to the length of the basal elements together, distally with two sensorial pustulae. Submarginal cell attaining two-fifths the length of the wing, 1.112 mm. long, with the anterior margin without fringe hairs. The wing brownish infumate in the apical two-thirds with a trace of the radial vein indicated by a slightly darker line. A colourless line in place of the discoidal vein. Hind wing (length 2.113 mm., breadth 0.452 mm.) hyaline; with three hamuli at 1.299 mm. from the wing base. A bare longitudinal broad area from the base to the middle of wing; another small hairless space just in front of hamuli. The longest hairs of the fringe near the base, 0.119 mm.

*Legs*.—Fore coxae (0.238 by 0.197 mm.) smooth, internally microscopically striate; pilosity basally dense and very short, sparse and longer distally. Trochanter (0.238 by 0.075 mm.) elongate, sparsely and evenly hairy. Femur (0.595 by 0.15 mm.) ventrally at the base with five round sensorial pustulae; pilosity denser and shorter dorsally to the distal end. Tibia (0.510 by 0.119 mm.) finely shagreened, densely hairy, distally with 14 strong spines (thickened hairs); spur (0.207 mm.) with the upper tooth twice as long as the lower one. Comb of the fore metatarsus (0.272 by 0.051 mm.) with about 60 spines. The tarsal joints 2-5 respectively 0.146, 0.133, 0.098, 0.139 mm.; claw, 0.068 mm.; pulvillus of each tarsus with peculiar basal paired elements (fig. 4, e), length 0.054 mm. (folded pulvillus).

Mid coxae (0.340 by 0.214 mm.) smooth, internally at the base microscopically transversely striate; the anterior surface with numerous small spines. Trochanter (0.194 by 0.082 mm.) with three pustulae. Femur (0.724 by 0.143 mm.) basally with four pustulae, very finely shagreened. Tibia (0.660 by 0.112 mm.) basally with five pustulae, with the pilosity slightly denser ventrally; distal ends of tibia and of tarsal joints 1-4 with a few longer and stronger bristles. Spur (0.170 mm.) with dense short spines. The tarsal joints 1-5 respectively, 0.262, 0.173, 0.142, 0.109, 0.142 mm.; claw 0.068 mm.; breadth of tarsal joints 0.054 mm.

Hind coxae (0.422 by 0.228 mm.) internally near the base with three short transverse rugae; trochanter (0.187 by 0.085 mm.) with three pustulae on the distal end

dorsally. Femur (0.823 by 0.160 mm.) basally with four ventral pustulae in one row. Tibia (0.976 by 0.119 mm.) basally with 4-5 sensorial pustulae and like the foregoing parts of leg, smooth basally with sparse pilosity, distally shagreened, with dense short pilosity; spur (0.187 mm.) with short spines. The tarsal joints 1-5, 0.570, 0.214, 0.201, 0.129, 0.153 mm.; joints 1-4 distally with stronger bristles.

*Abdomen.*—First abdominal tergite truncate in front, the anterior angles seen from above appearing like four rounded teeth. Spiracles lateral, immediately behind anterior margin, slightly projecting. Eight longitudinal dorsal parallel ridges. Lateral surface with a semicircular ridge bordering a small smooth space; about ten short radial ridges ramifying from the semicircular ridge. Base of tergite near the spiracles with 5-6 long, thick, parallel hairs from each side. Second tergite with 16 longitudinal ridges, of which 4 on each side anastomose and do not reach the apical margin of the tergite. Third and fourth tergites medially with 20 longitudinal ridges, laterally rugulose-punctate. Fifth basally with 16 ridges, only 4 median ones reaching the apical margin. Sixth at the middle coarsely punctate, each puncture with a strong erect hair, apically with a bundle of ten parallel bristles.

First ventrite coarsely reticulate, laterally with thin short pilosity, second ventrite basally with 16 large punctures in a transverse row, followed by six longitudinal ridges. On both sides, as on the third ventrite, a feeble tubercle. This tubercle finely, longitudinally aciculate, covered with numerous (nearly 40) pores, which lead into canals perforating the chitin, which is here thickened. As for the morphological significance of this structure, it is difficult to judge, since we know nothing of the anatomy of *Scelio*. Both sexes of different species have the same structure on ventrites 2, 3, 5. Third ventrite with 18 longitudinal ridges basally; apically with a large smooth shining space. Fourth and fifth medially smooth, laterally longitudinally rugulose-punctate without tubercles; fourth with two canals on each side. Sixth coarsely punctate, the punctures denser apically and laterally; the apical margin twice feebly sinuate. Terebra in a fine membranous sheath; length, 2.44 mm.; breadth, 0.136 mm.

The dimensions of the abdominal segments are:—

	I.	II.	III.	IV.	V.	VI.
Tergites: length ...	0.339	0.452	0.622	0.565	0.429	0.283 mm.
breadth	0.610	0.837	0.877	0.859	0.643	0.339 mm.
Ventrites: length ...	0.316	0.475	0.711	0.565	0.452	0.283 mm.
breadth	0.452	0.643	0.678	0.622	0.429	0.260 mm.

♂. Length, 4.5 mm. Similar to the ♀ in colour.

*Antennae* reddish brown; radicula, 0.105 mm. by 0.047 mm. Scape as long as the five following joints together, moderately curved. Fifth joint swollen, ventrally with a large longitudinal sensorium; joints 4-10 dorsally and externally with small sensoria (fig. 2, *h*), fourth with only one, fifth with nearly 20, sixth to tenth with nearly 70 (fig. 2, *g*). Third to tenth joints with their base merged into the distal ends of the foregoing joints. Sixth to tenth pedunculate.

*Mouth-parts.*—Mandible (0.337 by 0.134 mm.) externally with 14 bristles and 6 sensorial pustules; nearly straight, with blunt apical teeth.

*Thorax.*—Pronotum with shoulders a little more raised.

*Wings.*—Forewings (2.847 by 0.96 mm.) reaching the apex of fifth abdominal tergite, light brownish with pale veins and stigma.

*Legs* with the joints generally shorter and thicker than those of female, except for the longer 5th tarsal joints, claws and pulvillus; the comb of fore metatarsus with nearly 40 spines; fore tibia distally with 10-12 thickened hairs.

Dimensions of the legs :—

	<i>Fore.</i>		<i>Mid.</i>		<i>Hind.</i>	
	Length.	Breadth.	Length.	Breadth.	Length.	Breadth.
Coxa ...	0.233	0.219	0.282	0.221	0.398	0.245 mm.
Trochanter ...	0.238	0.078	0.170	0.075	0.170	0.082 mm.
Femur ...	0.595	0.156	0.673	0.143	0.782	0.167 mm.
Tibia ...	0.459	0.122	0.622	0.129	0.873	0.126 mm.
Spur ...	0.176	—	0.140	—	0.170	— mm.
1st tarsal joint	0.238	0.061	0.207	—	0.401	0.054 mm.
2nd " "	0.136	—	0.126	—	0.197	— mm.
3rd " "	0.119	—	0.085	—	0.153	— mm.
4th " "	0.098	—	0.078	—	0.095	— mm.
5th " "	0.160	—	0.150	—	0.160	— mm.
Claw ...	0.071	—	0.071	—	0.071	— mm.
Pulvillus ...	—	—	0.088	—	0.082	— mm.

*Abdomen.*—First to third tergites similar to those of female ; spiracles of the first tergite a little more prominent, forming two small lateral teeth ; second and third with 16 parallel ridges ; fourth with 22, fifth with 16, sixth with 8 parallel ridges, the latter laterally and apically rugulose-punctate ; seventh tergite with a few coarse punctures on the posterior edge. First abdominal ventrite coarsely punctate, with thick hairs arising from each puncture, laterally with fine dense pilosity ; second basally with 12 punctures in a transverse row, followed by a narrow smooth shining space, thence longitudinally rugulose-reticulate with a smooth median space ; third to fifth ventrites medially smooth with sparse hairs, laterally rugulose-reticulate ; second and third with large tubercles, each with nearly 60 canals, fourth with 6 and fifth with 2 canals ; sixth and seventh ventrites coarsely punctate, each puncture with a thick hair ; sixth with a median smooth space. Dimensions of abdominal segments :—

	I.	II.	III.	IV.	V.	VI.	VII.
Tergite :							
Length ...	0.304	0.520	0.621	0.520	0.340	0.158	0.102 mm.
Breadth ...	0.441	0.610	0.781	0.768	0.599	0.417	0.282 mm.
Ventrite :							
Length ...	0.282	0.588	0.643	0.565	0.599	0.203	0.102 mm.
Breadth ...	0.429	0.588	0.621	0.588	0.475	0.565	0.191 mm.

Genitalia consisting of a depressed short tube, in which two unequal joints can be distinguished : the shorter basal (length 0.221 mm.) and the longer distal (0.340 mm) ; the latter can be bent ventrally at a right angle. Distal end of genital tube (fig. 3, *j*) ventrally opened, and here with two small internal paramera bearing 4–5 teeth.

Type ♀ and ♂ in the collection of the Entomological Department of the Experimental Station, Poltava ; paratype ♀♀ sent to the Zoological Museum of the Russian Academy of Sciences and to the British Museum.

The species is named after Mr. B. P. Uvarov, our distinguished investigator of locusts.

### **Scelio nikolskyi**, sp. n.

♀. Length of body, 5.6 mm.

Black ; scape, mandibles (except extreme base), trophi and legs (except coxae), yellowish red ; tegulae and coxae (except yellowish apices) brown.

*Head* (fig. 5, *b*).—Length, 0.81 mm. ; breadth, 1.32 mm. ; height, 1.16 mm. Occiput large, broadly emarginated behind. Eyes inversely egg-shaped, ratio of long and short diameters as 11 : 9 (0.55 by 0.45 mm.). Vertex elevated ; ocelli in an



obtuse-angled triangle, round; diameter of ocellus  $85\mu$ . Temple broad, inferiorly inflated, slightly broader than the short diameter of the eye. Forehead distinctly dilated orally, from 0.6 mm. on the line immediately under the front ocellus to 0.93 mm. on the level of the inferior orbits. Frontal process 0.1 mm. long and 0.09 mm. broad, deeply excised at the apex, with 16 stout, thick hairs. Cheeks shorter than the shortest diameter of the eye (0.34 mm.), with an oblique sulcus genalis, which reaches

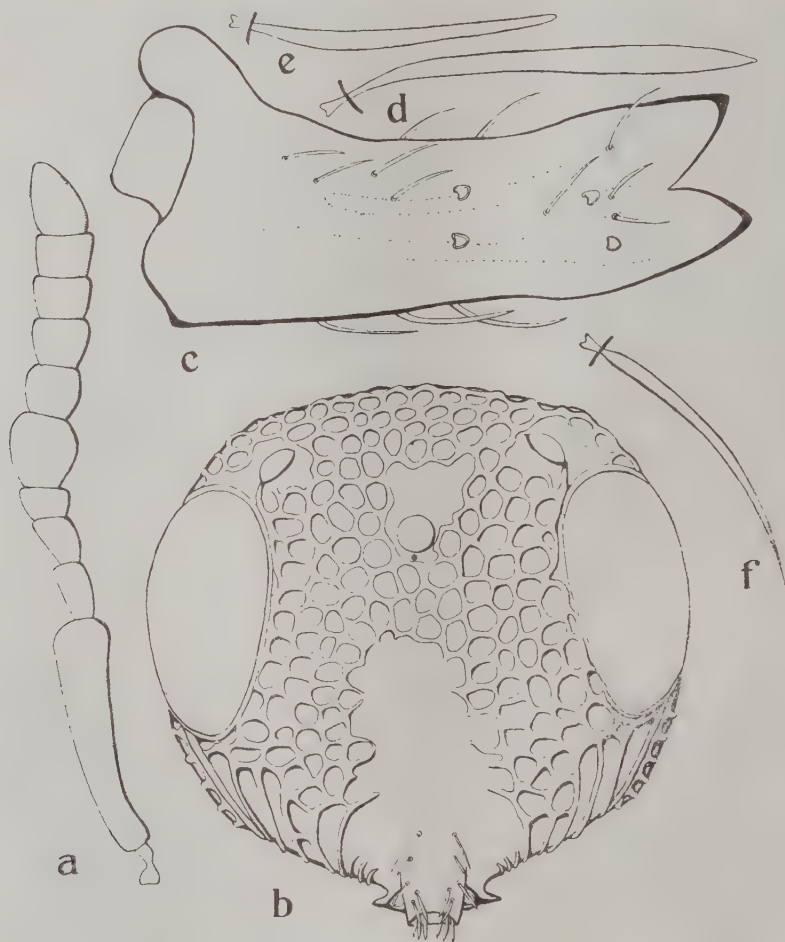


Fig. 5. *Scelio nikolskyi*, sp. n.: a, antenna of ♂; b, head; c, mandible; d, scale-like hair from the head; e, similar hair of *S. uvarovi*, sp. n.; f, similar hair of *S. vulgaris*, Kieff.

the eye-margin at the external orbit and is distinctly longer than the length of the cheek. The general surface of the head covered with large raised punctures, each one bearing a thick white hair. The hairs are longer on the temple and shorter on the forehead near the ocelli; maximum length 0.13 mm., breadth  $7\mu$ , distinctly dilated beyond the middle (fig. 5, d). The forehead on both sides with five longitudinal keels; the area close round each ocellus and the inferior three-quarters of the forehead

in the middle smooth, shining and bare. Clypeus (0.12 mm. long, 0.35 mm. broad) nearly trapeziform with the anterior border straight, slightly emarginated on both sides, the lateral angles projecting in form of two obtuse teeth; an elevated line, bifurcated at the end, connects this tooth with the torulus, the two branches forming the external border of the antennal base. The labrum as in *S. uvarovi* (0.02 mm. broad), with twenty stout apical bristles.

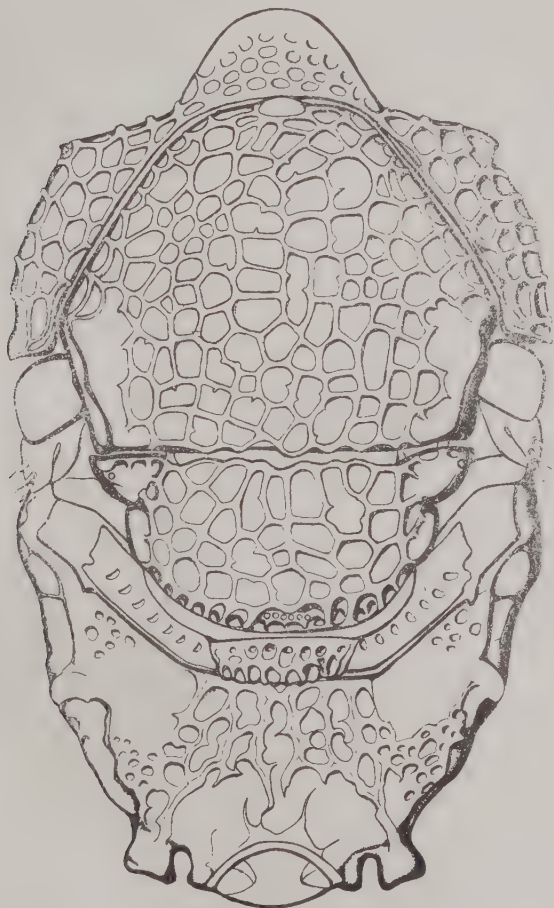


Fig. 6. *Scelio nikolskyi*, sp. n., thorax.

*Mouth-parts.*—Mandible (length 0.47 mm.; breadth, 0.23 mm.; length of tooth, 0.1 mm.) moderately curved, with two equal teeth apically, externally with 14 bristles and 4 sensoria (fig. 5, c). Maxilla I: cardo 6:7; stipes 24:23; lacinia with two stout bristles near the base of the palpus and with five terminal bristles; palpus three-jointed (lengths, 0.09, 0.067, 0.09 mm.) with 4, 6 and 10 bristles respectively. Palpus of maxilla II (lengths 0.062, 0.057 mm.) with the first joint bearing two, the second four bristles.

*Antenna*.—Bulla, length 0.13 mm., breadth 0.05 mm.; scape, length 0.67 mm., breadth 0.08–0.14 mm., distinctly dilated toward the apex, finely shagreened, evenly covered with fine dense hairs from 23 to  $37\mu$  long, ventrally smooth, the remaining joints are missing.

*Thorax* (fig. 6).—Length 1.77 mm., breadth, 1.08 mm. Pronotum from above 0.74 mm. long (at the middle 0.17 mm.), from below 0.96 mm. long, 1.08 mm. broad. Two longitudinal keels separate the dorsal surface from the ventral on the shoulders. Ventral surface reticulate-rugulose with a smooth space immediately under the keel. The dorsal surface, like the whole scutum of the mesonotum and scutellum, with large raised punctures, each with a thick scale-like hair. The spiracle at the upper posterior angle of the pronotum, diameter 0.05 mm. Pronotum postero-ventrally with eight short longitudinal ridges. Propectus (fig. 7, c) divided longitudinally, the postero-medial angles forming sharp teeth, smooth, with sparse tiny hairs at the middle, externally coarsely rugulose with a few thick hairs: the posterior margin opposite to

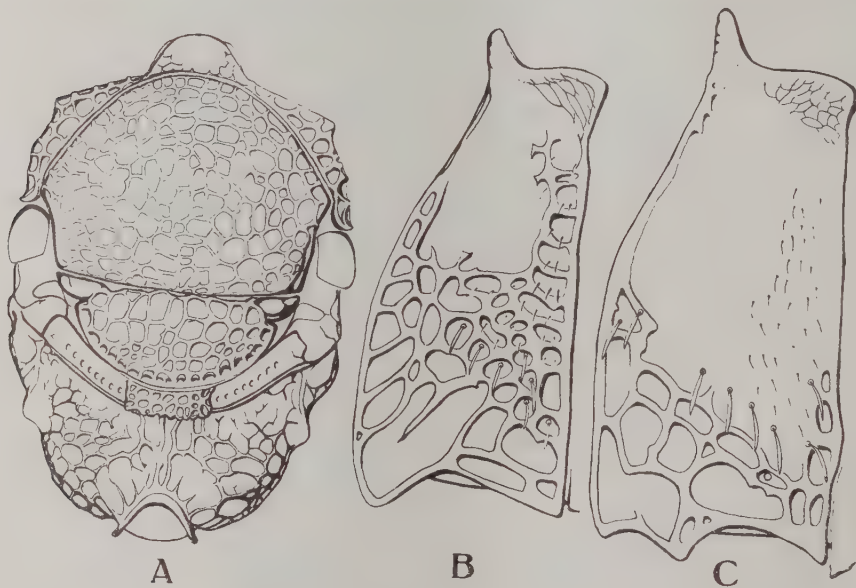


Fig. 7. A, thorax of *Scelio vulgaris*, Kieff.; B, right half of propectus of *S. uvarovi*, sp. n.; C, the same of *S. nikolskyi*, sp. n.

the fore coxa broadly excised. Mesoscutum 0.8 mm. long, 0.86 mm. broad; the large irregular punctures from 0.03 to 0.11 mm., increasing towards the disk; the wide space near the straight lateral border smooth, shining; the white scale-like hairs on mesoscutum and scutellum directed as in *S. uvarovi*. Scutellum 0.37 mm. long, 0.79 mm. broad, with produced anterior angles, each with one sensorial pustula. Scutellum separated from metanotum by a row of deep punctures, followed by a smooth space; on the posterior border with a row of six round sensorial pustulae among deep punctures. Mesosternopleurae 0.63 mm. long, length at middle 0.53 mm., breadth 1.3 mm.; the pleural part diagonally depressed from the base of the fore wing to the mid coxa, finely reticulate, bare. The anterior border of the mesopleurae and sternal part with sparse thick hairs. Sternal part coarsely irregularly reticulate, twice excised anteriorly, slightly produced to the mid coxae, the space between the coxae

with a few short longitudinal ribs and a central shallow groove. Tegula 0.17 mm. long, 0.14 mm. broad. The axillaries close together (generic character) with four groups of round sensorial pustulae; the first axillary with 4, 15 and 3, the second with 11 sensoria in three close rows, 3, 4, 4. Metanotum twice as broad as long (0.45 mm. by 0.9 mm.), length at the middle 0.11 mm. and 0.29 mm. broad.; lateral parts smooth, each with 7 small grooves; the median part elevated, irregularly rugulose anteriorly, with seven grooves in one row. Metasternopleurae 0.62 mm. long, 1 mm. broad, at the middle 0.4 mm. long; anterior border of the pleural part with a row of large punctures each bearing a thick hair.

Pleural part with seven longitudinal ridges, partly anastomosing. Sternal part divided by a longitudinal median suture, finely reticulate, with smooth spaces under the mid coxae and around the base of the hind coxae. Propodeon 0.8 mm. long, 1.07 mm. broad, length at the middle 0.33 mm., breadth at the spiracles 0.98 mm. The posterior angles produced into two robust blunt teeth, slightly dilated to the apex (length 0.08 mm., breadth 0.1 mm.). The dorsal surface at the middle with six longitudinal ridges, the lateral ramifications of these anastomosing ridges forming a rugulose surface on both sides of the propodeon. The dorsal part of the propodeon laterally covered with small silver hairs, which become denser towards the pleural area between the spiracle and the posterior tooth of the propodeon; this area densely covered with woolly short silvery hairs concealing the structure of the chitin. (The propodeon of *S. vulgaris*, Kieff., lacks the woolly field and the posterior teeth, fig. 7, a.).

*Wings* similar to those of *S. uvarovi*. Forewing with pale yellow stigma; length 3.4 mm., breadth 1.15 mm., one-third as broad as long, with the submarginal vein reaching two-fifths of the wing length (1.55 mm. long); the stigmal vein can be traced to the end (0.23 mm. long). Hind wing 2.6 mm. long, 0.59 mm. broad, the hooklets distant 1.6 mm. from the base; the longest hairs of the fringe 0.19 mm.

*Legs*.—Fore coxa (0.37 mm. by 0.25 mm.) anteriorly with three oblique rugae, with short pilosity on the inner side and longer hairs outwardly; the dorso-anterior surface shagreened. Trochanter (0.31 mm. by 0.01 mm.) with a few short hairs and four sensorial pustulae. Femur (0.7 mm. by 0.18 mm.) basally with four close sensoria, dorsally and distally with short pilosity. Tibia (0.6 mm. by 0.12 mm.) with fine short dense pilosity, distally with 26 thick spines; spur 0.24 mm. long, basally 0.05 mm. broad. Foremetatarsus (0.31 mm. by 0.08 mm.) with a comb of nearly 52 spines, distally with 12 stout spines; second joint (0.21 mm. by 0.05 mm.) with a ventral row of 11 spines, apically with 9 spines; third (0.15 mm. by 0.05 mm.) with 7 ventral and 5 apical spines; fourth (0.12 mm. by 0.04 mm.) with 5 apical spines; fifth, 0.18 mm. by 0.044 mm., claw, 0.08 mm.

Mid coxa, 0.53 mm. by 0.31 mm.; trochanter (0.22 mm. by 0.11 mm.) with two sensoria; femur (0.87 mm. by 0.17 mm.) with five close sensoria basally, smooth, with sparse short pilosity, denser on the scaly apical end; tibia (0.83 by 0.12 mm.) with four dorsal and one ventral sensoria basally, ventrally with a row of 26 spines, apically with 18 spines; spur 0.16 mm. long, with minute hairs. First tarsal joint (0.33 by 0.095 mm.) with 11 ventral and 17 apical spines; second (0.21 by 0.05 mm.) with 10 ventral and 7 apical spines; third (0.15 by 0.13 mm.) with 4 ventral and 5 apical spines.

Hind coxa (0.36 by 0.24 mm.) anteriorly with three oblique rugae and short pilosity, the ventral surface shagreened. Trochanter (0.24 by 0.12 mm.) with a few short hairs and two sensoria. Femur (0.99 by 0.2 mm.) basally with six close sensoria, externo-dorsally with sparse pilosity.

*Abdomen*.—Length, 3.16–3.19 mm., nearly four-sevenths of the body length. First tergite broadly excised anteriorly, with raised margin, laterally with two teeth visible from above; dorsally with ten parallel ridges from the anterior margin; laterally pilose, with about ten long parallel thick hairs. Second tergite basally with



a slight transverse depression, with 14 longitudinal ridges not reaching the apical border; apically with a smooth shining space. Third tergite with 18 ridges slightly divergent on both halves (9 and 9), distinct only basally, apically anastomosing and obliterated, leaving a semicircular smooth space. Fourth and fifth tergites medially with a smooth longitudinal line, the former with 14 and 14, the latter with 10 and 10 longitudinal ridges. Sixth tergite basally with 12 ridges, then rugulose punctate before the smooth apex. All the pleurae shining, smooth.

First ventrite coarsely rugulose, with large punctures basally, pilosity sparse but thick. Second ventrite basally with a transverse row of 12 deep punctures, with 11 anastomosing ridges not reaching the smooth apical margin; laterally at the middle, like the third ventrite, with a large tubercle, finely longitudinally striated, perforated by numerous pori. Third, fourth and fifth ventrites with a smooth median longitudinal line, third with 8 and 8, fourth with 10 and 10, fifth with 5 and 5 longitudinal ridges. Sixth ventrite with 14 elongate punctures, and bisinuate at the apex, with a bundle of ten parallel thick scale-like hairs. Measurements of abdominal segments:—

			I.	II.	III.	IV.	V.	VI.
Tergite:	Length ...	...	34	50	73	66	48	30
	Breadth ...	...	61	77	84	86	60	31
Ventrite:	Length ...	...	34	64	65	62	55	32
	Breadth ...	...	45	60	63	56	42	21

♂. Unfortunately the male specimen was lost, but Mr. V. Nikolsky made a sketch of its antenna good enough to judge of the proportions of the joints (fig. 5a). From this drawing we can see that *S. nikolskyi* belongs to the group of species with the considerably swollen fifth joint.

Described from two damaged female specimens bred from eggs of *Locusta migratoria* from the Perovsk district, Turkestan, by Mr. V. A. Nagaibakov, and communicated to me by the Central Asian Station for Plant Protection in Tashkent through Mr. B. P. Uvarov. Named after Mr. V. V. Nikolsky, our well-known specialist on locusts. The types will be deposited in the Zoological Museum of the Russian Academy of Sciences.

## NOTES ON THE BREEDING-HABITS OF TWO MOSQUITOS.

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*Government Economic Biologist, British Guiana.*

(PLATE XXXV.)

The observations herein recorded were carried out on a portion of the foreshore and of the low-lying front-lands in the vicinity of Georgetown, British Guiana, during the months of January, 1925, and July and August, 1926. The results obtained appear to be of sufficient interest to warrant their being placed on record as throwing further light on the breeding-habits of two important mosquitos of this Colony, namely, *Anopheles tarsimaculatus*, Goeldi, and *Aedes taeniorhynchus*, Wied.

The principal area in which the investigations were carried out is situated to the north of Kitty Village outside of the Sea Wall and is bounded on the south by that wall, on the west by the Kitty Groyne, and on the east by another groyne (Case Groyne) erected a few years ago as part of the sea-defences. The area measures roughly from east to west about 700 yards and from north to south about 200 yards at its greatest width, and about 60 yards at its narrowest part, these being situated at the western and eastern boundaries respectively. The accompanying sketch-map gives a general plan of the area. The places from which mosquito larvae were collected are indicated on the plan, *Anopheles* by black spots, *Aedes* by concentric rings.

### 1. *Anopheles tarsimaculatus*, Goeldi, in Saline Water.

Within recent years, and since the construction of the wall and other sea-defences in this locality, there has been a considerable making up of the foreshore east of the Kitty Groyne. The result of this reclamation has been the formation of a bank in front of the wall, a considerable portion of which now is never covered completely by the sea, but which at spring tides is broken over at certain places (indicated by arrows on the plan), and the low-lying parts then inundated. In these low places rain-water also collects during the wet season, forming pools that continue until the dry weather, becoming contaminated with salt water as mentioned above, or absorbing salts from the soil itself. As the low areas are situated principally along the base of the wall, and there is a ridge of higher land between them and the normal high-water mark, the greater part of the water which collects there from rain, or which enters during periods of high spring tides, cannot again escape, and stagnant pools are formed along the base of the wall. In these pools *Anopheles tarsimaculatus* was found to be breeding.

On this bank of foreshore a number of different plants have gained a foothold, predominant amongst these being a species of stiff grass, *Stenotaphrum secundatum*, Walt., known locally as "crab grass," and three species of sedges, *Fimbristylis spathacea*, Roth, *F. spadica*, Vahl., and *F. ferruginea*, Vahl., are of common occurrence. The vine, *Ipomoea biloba*, Forsk., the mangrove, *Dodonaea viscosa*, Jacq., and *Thespesia populnea*, Soland., are also present. Scattered about the area are many small courida trees, *Avicennia nitida*, Jacq., some apparently the stunted remains of the occupants of the foreshore before sea-defence works were commenced, at which time a large amount of courida was felled, others apparently young and of comparatively recent origin. The grass, *Stenotaphrum secundatum*, in addition to growing on dry ground, grows around the edges of the various pools and also on the swampy areas and even into the pools themselves, the courida having more or less similar habits.

That these pools have come about naturally, at least in part, is apparent from the fact that pools nos. 2 and 3 are what may be described as ground-pools, and are mere

depressions varying from  $\frac{1}{2}$  to  $1\frac{1}{2}$  inches in depth, over which, in common with the adjacent areas, the "crab grass" is growing, and which soon become dry on the cessation of the rains. Pool no. 5 is also a natural depression, but somewhat larger and deeper than nos. 2 and 3. The area comprising no. 10 pool is only flooded during the very wet weather or at high spring tides, and the same may be said of pools nos. 6, 7 and 8. Pool no. 4 is apparently not a natural depression and may have been formed in obtaining earth to make the path over the wall at 11. As regards no. 1 pool, the principal source of *Anopheles*, there can be no doubt that this condition has been accentuated, if not entirely brought about, by the construction of the sloping earth-path at the point 11 indicated on the plan, to enable horses to cross the wall and gain access to the foreshore. It would appear that had this ramp never been thrown up much of the water forming pool no. 1 would have made its way to the sea by way of the swampy piece of ground on the western side of the ramp, and between it and the Kitty Groyne, and then by way of the pool along the eastern side of that groyne (no. 9), which area is covered at every high tide.

In pool no. 1 large numbers of *Anopheles* larvae were found to be breeding at the western end near the foot-path at 11. At this point in the earlier part of the survey the larvae were effectively concealed amongst floating debris consisting of decaying vegetation, such as seeds and twigs, while during the second part of the survey they were often found amongst a thick foul scum that had accumulated at the western end of the pool. Some of the larvae were found amongst the grass growing along the edges of the pool and were thus somewhat shaded, and others were taken amongst the debris and must be considered as being exposed to the full sun, having no shade of any kind beyond that offered by the debris itself. On the whole one would not have expected to find *Anopheles* larvae under such conditions, usually associating them with cleaner surroundings, the pool, at this point, having the appearance of being more suitable to *Culex* larvae. These were the conditions in both January, 1925, and again in July and August, 1926. On the latter occasions the odour of the pool at this point suggested faecal contamination. Larvae of Tabanid and Stratiomyid flies were present in fair numbers. There were present also in the pool, particularly on the latter occasions, numerous natural enemies of mosquito larvae, such as predacious Coleoptera and Hemiptera, as well as fishes, some as large as eight inches in length. It is probable, however, on account of the shallowness and the vegetation about the edges, that none but the very smallest of the fishes were able to attack the mosquito larvae.

In January 1925, *Anopheles* larvae alone were found to be breeding in pool no. 1, and in conjunction with *Aedes taeniorhynchus* in July and August 1926. *Anopheles* larvae were also taken in pools nos. 4, 6, 7 and 8, being again associated with *Aedes taeniorhynchus* in pool no. 4 in January 1925.

The water in these pools was examined on various occasions to determine the salinity, and the results of such examinations are given below. The salinity was estimated by titration with silver nitrate and is expressed as grammes of sodium chloride per litre. It has not been thought necessary to differentiate between total salts and NaCl, as the differences probably would not be appreciable.

On 17th November 1924, *Anopheles* larvae were present in considerable numbers along the edges of pool no. 1, the salinity of the water in the pool being then 11.2 grm. NaCl per litre, as well as in pools 6, 7 and 8, and also again on 30th December of that year. On 6th January 1925, no larvae could be obtained from pool no. 1, in spite of very careful search, and on examination it was found that the salinity of the water had increased to 15.3 grm. per litre. On 12th January larvae were again present in pool no. 1, but were all of small size, and the salinity was found to have decreased to 14.3 grm. On 27th January no larvae were to be found again, and the water then contained 18.3 grm. NaCl per litre. On 29th July 1926, larvae were abundant in the pool, and the salinity was found to be only 3.8 grm. The salinity

increased to 4.5 gm. on 18th August, and on that occasion also *Anopheles* larvae were collected from this pool. In every case the larvae were reared to adults, which proved to be *Anopheles tarsimaculatus*, Goeldi.

Howard, Dyar & Knab, on the authority of Peryassu, give 19 per cent. sea-water with fresh water as the amount which the larvae of *Anopheles tarsimaculata* will tolerate to complete a normal development, some larvae being able to survive 20 per cent. for three days, and 30 per cent. proving a fatal amount to all in one day. The salinity of the sea-water used is not given, and, therefore, no definite figures with regard to the NaCl content are available. Assuming, however, that the salinity of the sea-water was as high as 30 gm. NaCl per litre, the percentages given above would represent 5.7 gm. for normal development, 6.0 gm. as a tolerable amount, and 9.0 gm. as a fatal amount. It will be seen from the figures given previously that the salinity obtained in these investigations has much exceeded these amounts, varying from 11.2 to 15.3 gm. NaCl per litre, and is therefore more than double the amount quoted above as a tolerable quantity for this species of *Anopheles*.

## 2. On the Breeding-habits of *Aedes taeniorhynchus*, Wied.

*Aedes taeniorhynchus* (fig. 1) is well known as an inhabitant of salt marshes in both North and South America. In British Guiana, in common with other countries which it inhabits, it may be found breeding on occasions in such localities in very large

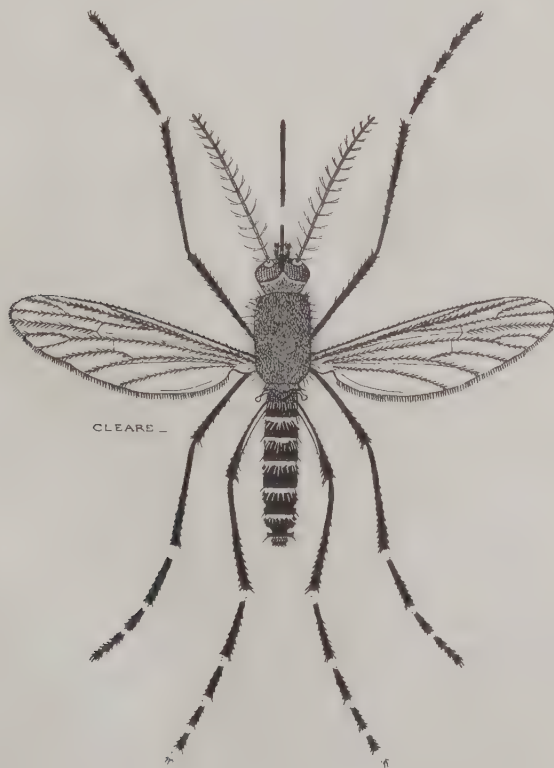


Fig. 1. *Aedes taeniorhynchus*, Wied., ♀.



numbers. In this country it usually appears abundantly soon after the breaking of the dry season and in certain districts becomes a veritable plague, and there are but few localities within a short distance of the shore where it is not to be found.

In June and July 1926, shortly after the breaking of a long, eight months drought (September to April), these mosquitos made their appearance in enormous numbers along the entire coastlands of the Colony, and even Georgetown, which is normally comparatively free from this insect, was swarming with them. During this period it was practically impossible for anyone to remain on the Sea Wall after dusk, especially on that section between Camp Street and Kitty Village, on account of the attacks of these insects. It was for this reason, while carrying out the latter part of the investigation on *Anopheles tarsimaculatus* described above, that this work was extended to include observations on *Aedes taeniorhynchus*. The results of these observations may prove to be of interest as coming from the southern extremity of the range of the species.

*Aedes taeniorhynchus* was first observed breeding on this foreshore on 30th December 1924, when larvae were collected from pools nos. 2 and 3, the salinity of pool no. 2 being at that time 14.5 grm. NaCl per litre. Larvae of this species were also found associated with larvae of *Anopheles tarsimaculata* in pool no. 4 on the same date, the salinity of the pool being 16.2 grm.

Observations were next made on 29th July 1926, when *Aedes taeniorhynchus* was again observed in both no. 1 and no. 2 pools. On this occasion in no. 2 pool they formed a seething mass, occupying almost the entire area of the pool, at that time about eighteen square feet, the salinity of which was then 1.6 grm. In no. 1 pool they were located in two small areas of the pool, about 6-8 sq. in. each in size, where the scum previously mentioned had been broken, and they had almost completely covered these spaces. The salinity of no. 1 pool was then 3.8 grm. On that date pool no. 4 was dry.

On 18th August larvae of this species were obtained from a small body of water that was separated from the main no. 1 pool by only a few inches of mud, and which obviously had at some time recently been connected. The salinity in this small offshoot, as it were, was then 5.2 grm.

A couple of days later (20.viii.1926) water had accumulated in no. 2 pool, owing no doubt to rains, and small larvae were found there in large numbers, the salinity of the pool being then 2.1 grm. Pool no. 4 also contained innumerable small larvae on that date, and the salinity was 3.8 grm. per litre.

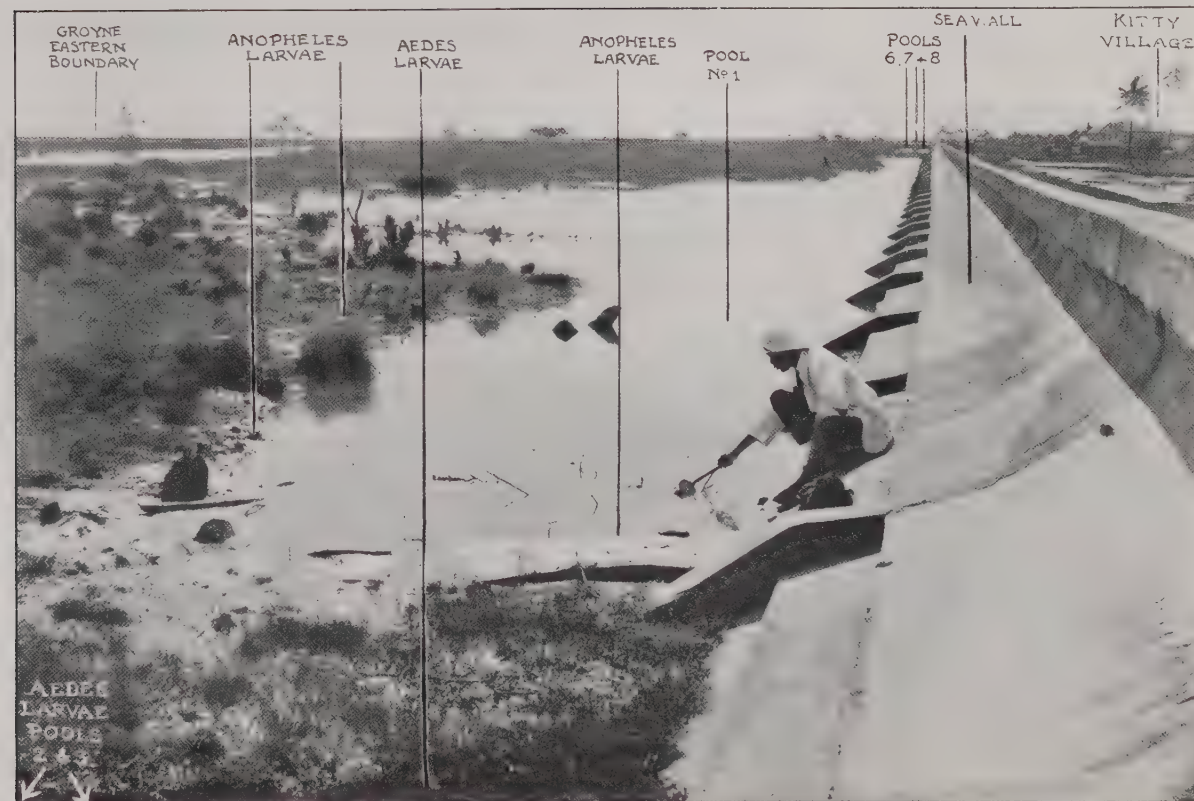
On 20th August collections were also made on the area immediately behind the Sea Wall west of the Kitty Groyne and east of Camp Street. This area consists of low-lying lands in close proximity to the sea and is overgrown with grass and scrub with large courida trees (*Avicennia nitida*) scattered over the area. It may be taken as typical of much of the coastlands of the Colony adjacent to the sea. Numerous depressions, varying from less than an inch to perhaps four or five inches in depth, are to be found over this area, and in such depressions larvae of *Aedes taeniorhynchus* were collected. In two such depressions where larvae of this species were obtained the salinity of the water was determined and was found to be 1.46 and 0.76 grm. The higher salinity was obtained from water from a depression of three or four inches, thickly grass-grown, on the borders of which a sedge known locally as "bizzi-bizzi" (*Cyperus* sp.) was growing. The water was fairly dark in colour and contained nearly full-grown larvae. The other sample of water was obtained from a shaded area under a courida tree, free from grass but with many leaves on the bottom and about two inches or less in depth. The larvae in this instance were small, and the water almost clear, and apparently it had not been standing for more than a couple of days and was no doubt the result of recent rainfall. These pools were situated about 300 or 400 yards from the Sea Wall and high-water mark, and the salinity must have

been produced by the dissolution of salts contained in the soil, which on the coastlands of British Guiana are known to be high and principally sodium chloride.

From the foregoing observations it is apparent that this mosquito will breed in water having a wide range of salinity, for it was obtained on these occasions in waters with salinities varying from 0.7 grm. to 16.2 grm. sodium chloride per litre. That *Aedes taeniorhynchus* breeds under conditions similar to those described above both in littoral swamps and in close proximity thereto on the coastal area of British Guiana there can be but little doubt, and this accounts for the swarms of this insect that are at times to be found along the coast of the Colony. That the habits here recorded closely agree with those of the species in its northern habitats is noticeable, except, perhaps, that in this Colony *Aedes taeniorhynchus* readily enters houses, and the writer has experienced occasions when it was necessary to make smudges of smoke in the houses themselves during the morning and early evening hours in attempts to repel these insects.

In conclusion I would like here to express my thanks to Mr. R. A. Altson, Assistant Botanist and Mycologist, and Mr. C. L. C. Bourne, Scientific Assistant, both of this Department, for the identification of the plants mentioned herein, and for the estimation of the salinity of the waters.



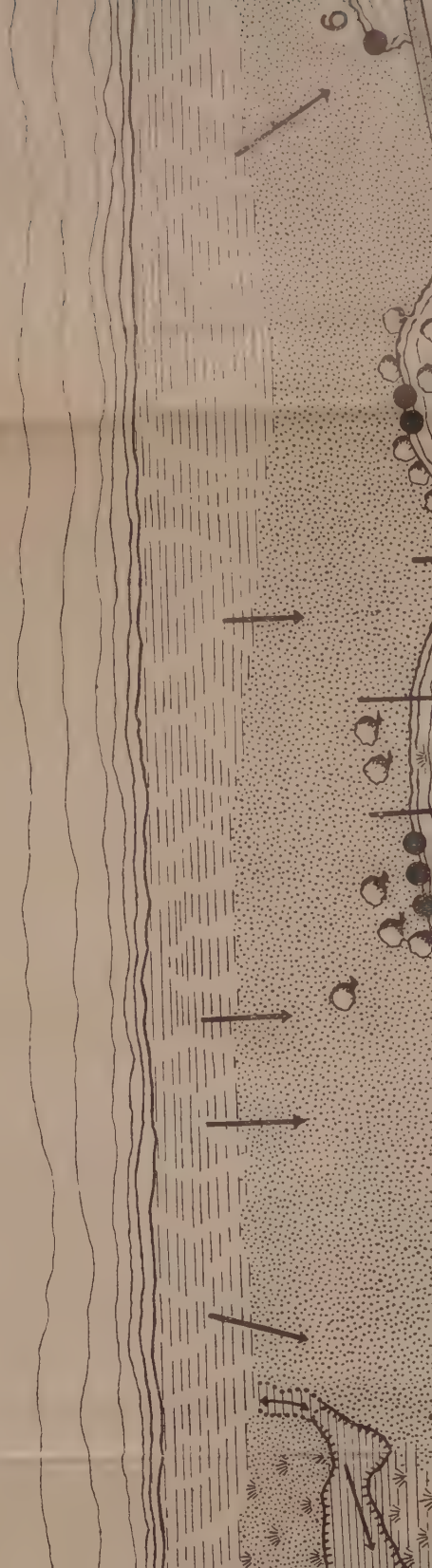


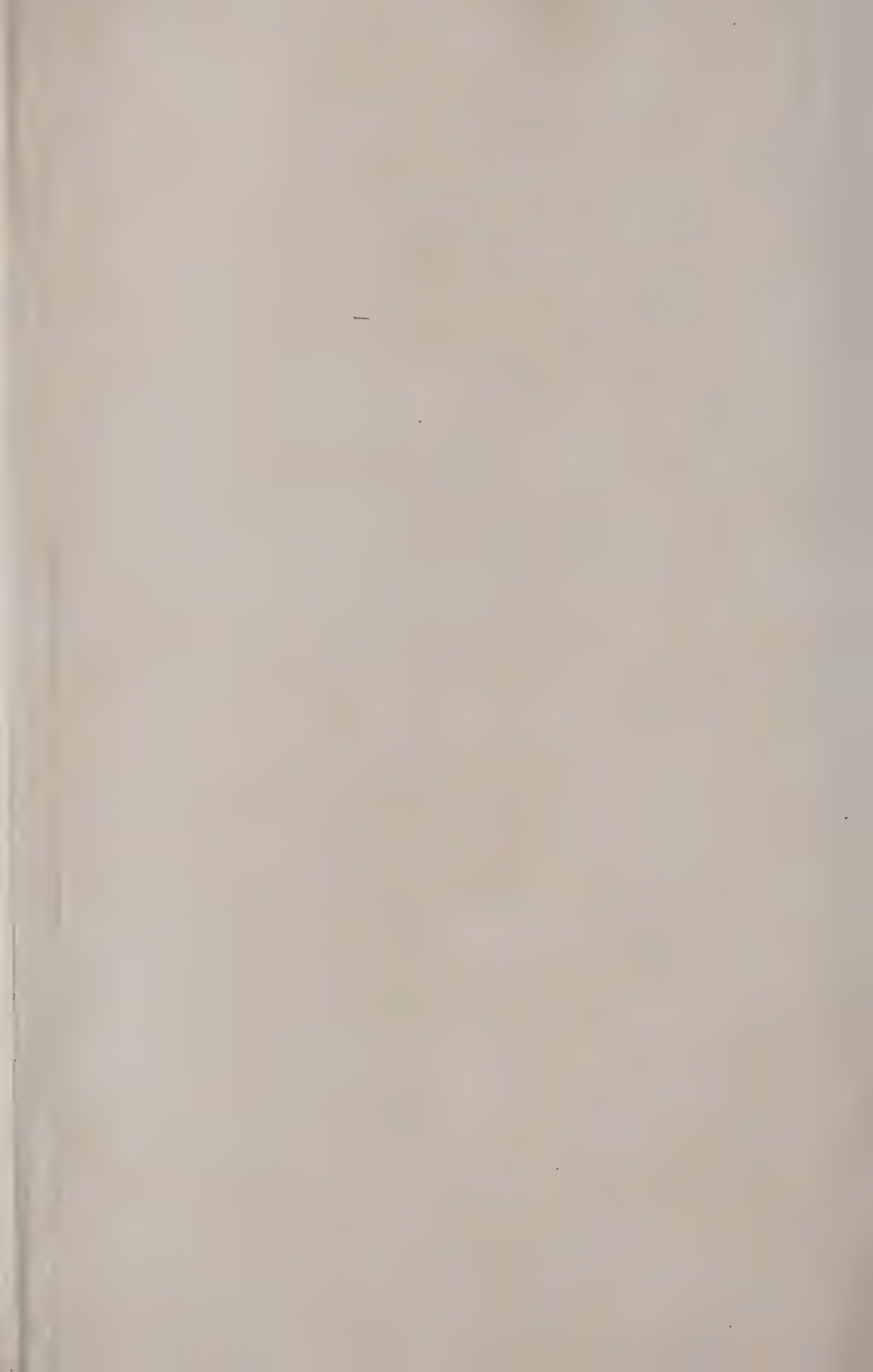
Kitty Foreshore, Georgetown, British Guiana, showing the mosquito breeding-areas in 1925-26.





ATLANTIC OCEAN





## NOTES ON THE BREEDING-PLACES OF TWO MOSQUITOS IN QUEENSLAND.\*

By R. HAMLYN-HARRIS, D.Sc.,  
City Entomologist, Brisbane.

Our present day lack of knowledge of the physical factors involved in the selection of breeding-places by certain types of mosquitos is to be deplored. Just why certain species choose particular types of water for their oviposition is a matter about which there is much conjecture, but it is hoped that in the near future some light may be thrown upon this subject by taking into consideration various aspects of the question hitherto uninvestigated.

Just what part the hydrogen-ion concentration plays in the matter remains to be seen; consideration of this is undoubtedly necessary, but we shall have to go further and try to get a proper conception of *all* the factors that influence mosquitos in their choice of breeding-places. Some authors are inclined to think that we shall find the solution of many of these questions in the food of mosquito larvae, and some useful work in this direction has been done by W. Rudolfs.

### ***Aedes argenteus*, Poiret.**

During quite recent times, owing to a paucity of results of any practical value, research has been forced to follow a different direction from that previously employed, and the fringe of the subject as to the preferential and compulsory breeding-places as applied to *Aedes argenteus* (= *Stegomyia fasciata*, F. = *A. aegypti* (L.) Dyar) has been touched by H. R. Carter in his consideration of the subject. There is no doubt that there is considerable regional variation in breeding habits, and if *A. argenteus*, a domestic mosquito, fighting for its very existence in areas where control measures are of a permanent nature, departs from the regular course, no surprise should be occasioned. So far as Queensland is concerned, it may be definitely stated that *A. argenteus* breeds in any receptacles holding fresh water, preferably in tanks, roof-gutterings, tins old or new (new for preference), water-jugs, and other vessels of a similar nature both indoors and out, but never in any water lying on the ground. Its choice of wooden vessels, such as water-barrels, seems to be restricted, so that the preferential breeding-places of this species may be stated to be those already referred to. The chief breeding-place in centres of population in Queensland seems to be the rain-water tank; and it is only very rarely that *A. argenteus* is not found breeding in a defective tank or in one inefficiently screened; but although this constitutes the main breeding-place of selection in the Greater Brisbane Area (385 sq. miles), we find this particular species quite frequently breeding in water that must not necessarily be regarded as a breeding-place of compulsion.

The association of *A. argenteus* with *Culex fatigans*, Wied. (*quinquefasciatus*, Say) seems to occur frequently, whenever the water in the vessel shows some slight degree of pollution, or perhaps a tendency to pH of 6.5 or thereabouts. This is singular, for although *Culex fatigans* might be described as an acidophile, *A. argenteus* certainly could not be thus designated, as it only very rarely selects water with an acid tendency; at least this has been our experience so far. Far more common is the selection of "spent" liquid manure as a breeding-place. During our surveys of the City areas we quite frequently come across vessels, principally old kerosene tins, containing liquid manure, more or less in a "spent" condition, *i.e.*, deprived of its characteristic

\* From the Entomological Section of the Department of Health, Brisbane City Council, Queensland.



salts, and such breeding-places are undoubtedly selected from choice and not from compulsion. It is more than likely that the odour has something to do with it, for more often than not the odour is only that of a mild hay infusion, and such vessels are usually found in shaded spots, such as out-houses, or stowed away under the house, just where the males would naturally be inclined to linger; and it is hardly likely that the food supply under these conditions would play much of a part, because *A. argenteus* is a bottom-feeder. But we are not at the present time in a position to say of what the main food supplies of this species consist, and many of its breeding-places contain none of the usual food materials commonly utilised by other species.

Buxton & Hopkins in their paper on "Race Suicide in *Stegomyia*" have recently drawn attention to the fact that *Aedes argenteus* is definitely attracted by hay infusion, and one would be inclined to think that this "spent" liquid manure contains the same attractive features as such an infusion. No instance in which *A. argenteus* has been found breeding in fresh manure is on record.

The choice for breeding purposes of brick- and cement-lined places holding water seems to be restricted to two or three species, and the association of *A. argenteus*, *A. (Finlaya) notoscriptus*, Skuse, and *Culex fatigans* with such breeding-places is suggestive in itself. The presence of *A. notoscriptus* is particularly so, because it usually prefers to breed in tree-holes, or in vessels provided with an ample food supply of leaves and plant stems, in jars or flower-vases in which the flowers have faded and only a small proportion of the water remains; hence its presence in large numbers in the Brisbane Cemeteries. A fair number of samples of water taken from such jars were examined and proved to be invariably alkaline, the pH varying from 8.0 to 9.0. As a rule *A. argenteus* prefers water of a different type from that selected by *A. notoscriptus* and only rarely selects such water as I have just referred to, which usually is of an alkalinity in the region of pH 8.5. The examination of the contents of some 400 flower-vases, taken from graves in one of the largest of the Brisbane Cemeteries, discloses the fact that *C. fatigans* breeds most frequently in such collections of water, and that now and then *A. argenteus* occurs in association with it (1.25 per cent.), usually in dirty water of which in every case the odour is similar to that of a hay infusion, with an added characteristic odour resembling that of decaying herbage, which appears to be constant in such samples. How far the value of any particular water from the breeding standpoint may be enhanced by the assistance lent by its natural surroundings or by particles of floating vegetation giving a suitable landing stage during oviposition, it is difficult to say, though one is inclined to think that Carter is right when he suggests that these may be factors in the mosquito's choice of places for oviposition. It is fairly certain (as we know from personal observations) that mosquitos do not attempt to lay their eggs in jars where the water is difficult of access. The type of water in which *A. notoscriptus* breeds in these cemeteries is apparently the same as that selected by *A. argenteus*, and yet *A. notoscriptus* has not been found associated with either *A. argenteus* or *C. fatigans*, but for this no explanation can be suggested.

Our surveys further disclose the fact that mosquitos prefer earthenware vessels to glass. Glass is apparently unattractive, possibly because it takes up too much heat and retains it during the greater part of the day, when these graves are as a rule unprotected by shade.

### **Anopheles (*Myzomyia*) annulipes, Walker.**

The dominant Anopheline mosquito of Southern and Western Queensland is *Anopheles annulipes*, Walker, and no one acquainted with its distribution and life-history would consider it fastidious in the selection of its breeding-places.

Some recent surveys of vacant lands, made within a three-mile radius of the City of Brisbane, enable us to record the following types of breeding-places for this species :—

In natural waters, both permanent and temporary, along the edges of quiescent pools and the more secluded portions of streams ; in fresh water swamps and in slowly trickling water provided with ample vegetable growth ; in borrow-pits along the sides of roads ; in water-holes, hoof-marks, etc., frequently muddy and sometimes more or less polluted ; in shallow water in water-troughs and barrels containing algae ; and finally, in salt or brackish water.

The consideration of these breeding-places of *A. annulipes*, though suggesting that this species will breed in almost any type of water available at the time, really leads us to the conclusion that food is the main determining factor in its choice of selection, and that not one of them is chosen from compulsion. A careful study of each breeding-place in the field tends to confirm this opinion. *A. annulipes* lays its eggs in shallow water and is purely a surface-feeder, the young larvae being entirely dependent upon minute vegetable growths or small animalculae which float near the surface, bacteria, particularly the larger varieties, forming an important part of their food.

The larvae of associated forms, such as *C. fatigans*, can subsist on very much coarser vegetation,\* as well as on decaying organic matter, and are therefore found in the same water, side by side, only when suitable food available for both species is present in sufficient quantities.

A second factor in the choice of breeding-places is the dependence of the Anopheline larva upon the warmth of the sun. *A. annulipes* is one of those mosquitos that do not seem to be influenced in their breeding to any great extent by the cold weather conditions of the Southern Queensland climate, and the larvae of this Anopheline can be found at any time of the year, in some instances in quite astonishing numbers, despite the unfavourable season of winter, nor do they seem to exhibit that low vitality which is distinctly noticeable with certain other types of mosquitos. Yet during the coldest days of winter, when the temperature goes to about 60° F. (the mean winter temperature, during June, July and August, for Brisbane is 59° F.) Anopheline larvae have a tendency to disappear temporarily until the temperature has materially increased as the day advances.

From the standpoint of hydrogen-ion concentration, the examination of waters in which *A. annulipes* has been found breeding seems to show a definite toleration limit of 6.5 to 7.5, for only in one instance has this limit been exceeded. The exception (doubtless others may come to our notice in course of time) is an interesting case of an *annulipes* having selected water in a ditch standing in close proximity to an effluent of a septic tank ; as the ditch became more and more influenced by this condition of affairs, the pH rose to the region of 8.0, but it is evident from actual observation that the food supply constituted a greater attractive force than the water itself.

Certain species of *Nitella* are supposed, without sufficient justification it would appear, to be toxic and to make the water in which they occur repulsive to mosquitos. There are some large patches of *Nitella* in shallow running water in the Kedron Brook at Enoggera, in which *A. annulipes* occurs in exceptionally large numbers ; and the well nourished condition of the larvae of *C. annulirostris*, Skuse, and *G. fatigans*, which are to be found breeding side by side with it, is ample evidence of the fact that food cannot be scarce in such waters.

The pH of the waters in which *Nitella* has been found in this area has been always in the region of 7.0. After *Nitella* has been left standing in a glass vessel covered with water for a fortnight the pH goes up to 8.0.

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\* Larvae of *C. fatigans* have been observed devouring thick stalks of wild watercress (*Nasturtium officinale*).

Under normal conditions, *A. annulipes* is a natural-water breeder, but it often seems to prefer a condition of semi-pollution and is quite frequently associated with *C. fatigans*.

In 180 instances in which *A. annulipes* was definitely located breeding, it was found 59 times in association with *C. fatigans*, and once with *C. fatigans* and *C. annulirostris* together; 17 times in association with *C. annulirostris* alone; 3 times with *C. annulirostris* and *Aedes (Ochlerotatus) alboannulatus*, Macq., together; and only once with *Mucidus alternans*, Westwood, in brackish water. The vegetation on the edges of water-holes would insure to *A. annulipes* sufficient protection against this last predacious species, the most frequent association of which is with *Aedes (O.) vigilax*, Skuse, which it devours greedily.

Such "association values" are likely to vary from time to time according to the weather conditions prevalent. Our surveys have shown that the nature of certain breeding-places is liable to alter at different seasons of the year, owing, for example, to the temporary pollution of the water during periods of drought, and this leads to a change in the species of mosquitos that select such breeding-places for oviposition.

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TWO NEW SPECIES OF *APANTELES* (HYM., BRACONIDAE).

By G. T. LYLE. 10.

***Apanteles thompsoni*, sp. n.**

♀. Black, shining; palpi pale; antennae beneath fusco-testaceous; clypeus and mandibles rufo-testaceous; belly at base testaceous; sides of abdominal segments 1 and 2 fusco-testaceous; legs testaceous, with hind coxae black or blackish, hind femora and tibiae slightly infuscated at tips, and hind tarsi more or less infuscated. Wings subhyaline, stigma pale fuscous, nervures paler but usually visible to the extreme margin of the wing.

*Thorax*: Mesothorax smooth, shining, feebly punctate; scutellum and metathorax smooth and shining. *Legs* with spurs of hind tibiae half as long as the metatarsus. *Abdomen* with first segment rather more than twice as long as its medial breadth, with sides parallel for half its length then narrowed to the almost truncate apex, smooth with some faint lateral striation; second segment rather more than half as long as third with two oblique impressed lines converging forward and enclosing a triangular space, smooth and shining like the remaining segments. Terebra briefly exerted, barely surpassing the anus.

Length, 3 mm.; expanse, 5-6 mm.

Cocoons pure white, covered with loose filaments.

Described from eleven females; the male is at present unknown.

This species can be referred to Marshall's Section IV of the genus (Spec. Hym. Eur. iv, p. 476) and to the Section III mentioned in my notes (Entom. xlix, p. 125). It approaches nearly to *A. lautellus*, Marsh., but that species has the terebra considerably exerted, is usually much paler in colour, and constructs a very different cocoon; closely allied also to *A. umbellatarum*, Hal., which, however, is much smaller and has the terebra half as long as the abdomen.

An insect of considerable economic importance; it has been proved to attack, as a solitary parasite, the destructive larva of the corn-borer, *Pyrausta nubilalis* (Lep. Pyralidae). The material from which the above description is taken was obtained in May 1925 at Lille, Nord, and was forwarded by Dr. W. R. Thompson of the American Corn-borer Laboratory, Hyères, after whom I have ventured to name the species.

***Apanteles diparopsidis*, sp. n.**

♀. Black; palpi pale; legs testaceous, coxae black, hind tibiae slightly infuscated at apex and hind tarsi infuscated except at extreme base. Wings whitish, stigma fuscous, with a more or less distinct pale spot at the inner angle, costa fuscous, other nervures paler, often almost decolorous, with the exception of the first abscissa of the radius and the first transverse cubital.

*Thorax*: Mesothorax punctate, scutellum smoother, shining; metathorax subgranulate, with a medial, depressed, smooth, margined area, from the centre of either side of which branches a transverse carina. *Abdomen* with first segment almost twice as long as its medial breadth, with parallel sides, truncate at the apex, rimulose; second segment less than half as long as third, smooth and shining, as are the remaining segments. Terebra  $\frac{3}{4}$  to  $\frac{1}{2}$  as long as the abdomen, somewhat decurved, the valves subclavate.

♂. Similar, but with the first abdominal segment narrower, the middle femora and trochanters streaked above and below with fuscous, and the middle tibiae apically fuscous; hind femora and trochanters and apical two-thirds of hind tibiae fuscous.



Length, 2-3 mm.

Cocoon pure white. (The only example to hand is damaged, but it appears to have been covered with loose filaments.)

Described from one male and two females bred from larvae of the red boll-worm, *Diparopsis castanea*, Hmps., taken at Rustenberg, Transvaal, by Mr. A. J. Smith, 4.iv.1925.

As is usual in closely allied species, it is likely that the dark markings on the legs vary in extent, and a damaged female I have seen appears to have the legs coloured much as in the male described above.

Bears a great resemblance to *A. xanthostigmus*, Hal., but differs from that species in having the 1st abdominal segment longer and the stigma differently coloured; also very like *A. emarginatus*, Nees, which, however, has the metathorax rugulose, with a medial channel and not areated.

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## ON THREE NEW SPECIES OF ICHNEUMONIDAE.

By D. S. WILKINSON, *W.*

Senior Assistant, Imperial Bureau of Entomology.

## PIMPLINI.

***Rhyssa persuasoria himalayensis*, subsp. n.**

May be separated from *Rhyssa persuasoria*, L., only on colour differences, of which the most important are as follows: Mesonotum with white signature, which is anteriorly acute and posteriorly broader, with sometimes the posterior angles somewhat drawn out behind; all coxae black and white, except in the male, in which the four anterior coxae are almost entirely white; hind legs, particularly hind femora, mainly dark to nigrescent or deep black, except in the male, in which the hind femora are mostly white; the white lateral markings of the 7th tergite contiguous with their white apical spots respectively, except in the male.

INDIA: 7 ♀♀ and 1 ♂, labelled as follows:—3 ♀♀ (of which one is the type) Kanasar, 5,500 ft., Chakrata, U.P., 23.vi.1923, ex log of *Cedrus deodara*; 1 ♀, Kanasar, 7,000 ft., Chakrata, 26.vi.1923; 1 ♀, Deoban, 9,000 ft., Chakrata Div., 17-18.vi.1923 (Dr. C. F. C. Beeson); 1 ♀, Deoban, Chakrata, U.P., 9,000 ft., 7.vi.1923 (Dr. S. K. Pillai); 1 ♀, Kashmir, Gulmarg, summer 1913 (F. W. Thomson); 1 ♂, Chakrata District, Korawa Khud, 9,100 ft., 4.v.1922 (S. N. Chatterjee).

Type in British Museum.

The signature on the mesonotum varies extensively in size, in one specimen occupying about three-fourths of the length of the mesonotum, in four specimens about half the length, and in two specimens one-fourth or less, and in one it is altogether absent; while it should be recorded that Dr. Roman, of the Riks Museum, Stockholm, to whom I am much indebted for assistance in this matter, has seen a large Swedish female of *persuasoria* with such a signature, but a small one.

The specimen of *persuasoria himalayensis* that is without the white signature on the mesonotum is also without any white on its hind coxae, and its anterior coxae have only a small touch of white. The British Museum possesses a German specimen of *persuasoria*, a male, with the four posterior coxae black and with the anterior pair black with a touch of white, and also a female from the Northern Islands of Japan, which has the four anterior coxae black and white, with the posterior pair entirely black; in neither case, however, is the white mesonotal signature present, and in the case of the German specimen the hind legs are red, but in the Japanese specimen the hind femora are distinctly darkened. Dr. Roman has seen a Finnish female "with quite blackish coxae."

The continuously white border of the 7th tergite occurs in the Japanese specimen referred to above, and also in one or two German specimens in the possession of the British Museum, but these, however, exhibit neither the nigrescent hind legs, the black and white coxae, nor the white signature on the mesonotum.

*Rhyssa persuasoria* commonly parasitises various species of *Sirex*, notably *Sirex gigas*, in Europe. *Sirex* is known to occur in India and it is very possible therefore that the host in this instance was a species of this genus.

## CAMPOPLEGINI.

***Anilastus laphygmae*, sp. n.**

Black; mandibles (except teeth), palpi, the four anterior trochanters, all the trochantines, tegulae, and hind tibial spurs, yellowish stramineous; the four anterior

coxae, all the femora, the four anterior tibiae, the abdominal tergites from the 2nd segment on (except as noted below), red testaceous. The abdominal tergites exhibit a large black marking basally; on the 2nd tergite this marking occupies the whole of the basal half of the tergite, thence being drawn out to a point towards but not quite reaching the apex of the tergite; the base of the marking on the 3rd tergite does not extend completely across the base of the tergite, and the marking is more or less triangular, its pointed apex not quite reaching the apex of the tergite; in the males, the markings on the 4th, 5th, and 6th tergites are decidedly smaller and basally reach hardly half-way across the base of the tergites, but being more or less drawn out to a point apically they still largely retain their triangular shape: in the females, however, the markings on the 4th, 5th and 6th tergites are even smaller basally, so that virtually all triangular shape is lost, the markings on these three tergites appearing as a more or less continuous dark stripe along the top of the tergite; the 7th tergite appears to be mostly dark. Antennae dark brown-red to blackish-red; hind tibiae more or less pale with some darkish markings basally and apically; the four anterior tarsi reddish testaceous, the hind tarsi brownish; stigma and wing veins faintly coloured pale brownish-reddish; visible abdominal ventrites yellow.

♂♀. Virtually all the integument subcoriaceous and clothed with a white, more or less long, pubescence of varying length. *Head* viewed from front triangular; antennae long and slender, with about 30 joints, and about 4.5 mm. in length. *Thorax*, including propodeon, about 1.6 mm. in length. *Propodeon* with distinct carinae; basal area always complete, four-sided, with the apical side considerably smaller than that of the base; the carinae of the areola usually strong as far as or a little beyond the point of emission of the usually fairly strong costulae, the areola becoming more or less obsolete apically, or its limitations being but faintly indicated; the petiolar area but faintly indicated; areola at greatest width about 0.14 mm.; costulae from about 0.22 to 0.24 mm. in length. *Wings* with the stigma more than three times as long as broad; areolet long petiolate, but the form and occurrence of the areolet is irregular in that either the external transverse cubital nervure may be absent, or all trace of the areolet may be absent, the transverse cubital being straight and interstitial with the recurrent; the recurrent is always in exact prolongation of the line of the basal half of the transverse cubital. *Legs*: hind coxa with its trochanter and trochantine about 0.83 mm. in length; hind femora averaging about 1.07 mm. long by 0.24 mm. at greatest width; hind tibiae varying in length from 1.25 to 1.35 mm.; hind tarsus from 1.5 to 1.7 mm., with its basal joint from 0.67 to 0.7 mm. long, the longer tibial spur being just slightly longer than half the length of the basal joint of the hind tarsus. *Abdomen*: basal portion of petiole more or less cylindrical and less than 0.15 mm. in breadth; the breadth of the petiole at the spiracles 0.3 mm., and the apex about as broad; the distance of the spiracles from the apex of the petiole also 0.3 mm., the postpetiole therefore in plan being more or less square; the total length of the petiole 0.81 mm. The length of the dorsal plate of the 2nd segment varies between the extremes of 0.71 and 0.81 mm., its basal breadth being from 0.3 to 0.36 mm., with its apical breadth about 0.6 mm.; the gastrocœli conspicuous; the 3rd segment about 0.55 mm. long, and the total length of the abdomen about 3.4 mm.; the petiole and abdomen, apart from the previously noted condition of the integument, devoid of sculpture; the ovipositor, whose apparent length is about 1.4 mm., slightly curved upwards, its sheaths being at least 0.6 mm. long.

SOUTH AFRICA: Pretoria, Transvaal, 21.ii.1919, 3 ♂♂ and 3 ♀♀, and 3 damaged specimens of indeterminable sex.

Received from the Division of Entomology, Pretoria. Bred from the larvae of a Noctuid moth, *Laphygma exempta*, Wlk.

*Type* in British Museum.

Dr. Roman, of the Riks Museum, Stockholm, who kindly examined this insect for me, pronounces it to be a new species of *Anilastus* and states that the Riks Museum possesses a pair from Damaraland.

## PRISTOMERINI.

***Pristocelus fumipennis*, sp. n.**

♂ ♀. Head, about 27 apical joints of antennae, mandibular teeth, mesothorax, propodeon, apical half of petiole, and notum of 2nd segment entirely, deep black; scape, basal two joints of flagellum somewhat, clypeus mostly, mandibles (except teeth), palpi, prothorax, tegulae, scutellum mostly (except that in the female it is darker), fore and middle legs, hind coxae, hind trochanters and trochantines, hind femora of male basally and also somewhat at extreme apex, of female almost entirely, tibiae (except about basal and apical sixth), basal half of petiole, red testaceous; median portion of hind femora of male, and basal and apical sixth of hind tibiae, hind tarsi entirely, dark reddish brown-black; notum of 3rd segment largely red testaceous with some black, the 4th segment as 3rd but with more black, 5th and 6th mostly black; stigma and wing-veins brown, wings hyaline except that in the forewings the apical half of radial cell, apical half of 3rd discoidal cell, and about apical sixth of anal cell, are infumate.

♂. *Head*: face punctate and pubescent, with a raised median area; clypeus separated and not or hardly punctate; flagellar joints 30-32; ocelli large, reaching to the orbits and occupying nearly the whole of the vertex, which is impunctate and more or less without pubescence. *Thorax*: mesonotum punctate and very slightly pubescent; basal depression of scutellum with strong lateral carinae; scutellum smooth and impunctate; mesopleurae and mesosternum punctate and strongly pubescent, except for a bare smooth raised area at the top of the mesopleurae beneath the insertion of the hind wings; propodeon with at least eleven superior areae; basal area quadrilateral and impunctate; areola impunctate, somewhat broader at the apex than base, more than three times as long as basal area, about two and a half times as long as its own extreme breadth, which is at a point about one-third total length from base, and which is at least three times as broad as apex; actual length of areola about 0.48 mm.; petiolar area two-thirds as long as areola and apically somewhat broader than its extreme width, impunctate but with three or four weak transverse carinae; dentiparal areae coarsely, and spiracular areae somewhat coarsely, punctate; the areae corresponding to the postero-intermedial and the postero-external areae combined impunctate but with three or four weak transverse carinae; remainder of the propodeon as punctate as the mesopleurae. *Wings*: nervus parallelus inserted distinctly above middle of brachial cell; nervulus interstitial or very slightly postfurcal; nervellus slightly but distinctly broken. *Legs*: the teeth towards the apex on the underside of the four front femora minute. *Abdomen*: postpetiole finely striate on the sides, and without pubescence; the notum of the 2nd segment without pubescence, finely striate except in the middle, which is more or less smooth; remaining segments unsculptured and sparsely pubescent; petiole about or hardly as long as 2nd segment, longer than the 3rd segment. *Length*, 7.25 mm.; wing expansion, 10.0 mm.

The integument of the frons, vertex, posterior orbits, middle coxae somewhat, hind coxae strongly, hind femora and tibiae, and the tergites and ventrites of the 3rd and succeeding abdominal segments, sub-coriaceous.

♀. As for male, except that the areola is very slightly punctate and is only about twice as long as extreme breadth; the petiolar area exhibits about seven weak transverse carinae; the postpetiole is broader and completely finely striate; the notum of the 2nd segment is completely finely striate, as is also the basal half of the notum of the 3rd segment; and that the petiole is longer than the 2nd segment, which in turn is



larger than the third. *Length*, 8.5 mm.; wing expansion, 10.5 mm.; ovipositor, 4.5 mm.

FEDERATED MALAY STATES: Kuala Lumpur, 1♀, 3♂♂ (G. H. Corbett).

*Type* in British Museum.

The male (*type*) and one female from a Pyralid larva on *Desmodium gyroides*, 10.i.1925; one male from *Lamprosema diemenalis*, Guen., 10.i.1925; the remaining male from *Pycnarmon cribrata*, F., 6.v.1925.

Up to now only two species have been assigned to the genus *Pristocelus*, namely *P. atriceps*, Szep. (Gen. Insectorum, fasc. 34, p. 48, 1905), from New Guinea, and *P. stimulator*, End. (Stett. Ent. Zeit. lxxxii, p. 9, 1921), from Sumatra. *P. stimulator* is separable from both *P. atriceps* and *P. fumipennis* on account of its yellow head, to name but one character. *P. atriceps* has the stigma yellow and only the base of the 2nd abdominal segment black, thus being easily distinguishable from *P. fumipennis*.

It was not, however, without certain misgivings that I assigned the present species to the genus *Pristocelus*, since the teeth on the four anterior femora are so very minute. It is possible that this is a form intermediate between *Pristomerus* and *Pristocelus*, and that further material or other closely related species may ultimately necessitate the submergence of this latter genus.

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# PARASITES DE *PERRISIA PYRI*, BOUCHÉ (DIPT., CECIDOM.)

par CH. FERRIÈRE, D.Sc. (Berne). *W*

Les parasites suivants ont été recueillis par Mr. J. G. Myers à Versailles, France, en juillet et août 1925, de la Cécidomyie des poires, *Perrisia pyri*, Bch. Le matériel obtenu comprend les 10 espèces dont les noms suivent, avec indication de leurs dates d'éclosion, mais seuls les deux *Platygaster* et le *Torymus* peuvent être considérés comme ayant une importance dans la destruction de la Cécidomyie, les autres espèces n'ayant été obtenues qu'en très petit nombre ou n'étant probablement pas parasites de ce petit Diptère.

## Fam. SCELIONIDAE.

### 1. *Inostemma boscii* (Jur.).

Cet *Inostemma* se distingue des autres espèces du même genre par son corps noir et brillant, ses ailes hyalines, et par la corne du 1er segment abdominal qui s'étend jusqu'au dessus de la tête. Il diffère nettement de *I. piricola*, Kieff., qui a été obtenu par Marchal de la *Contarinia pririvora*, Riley, en particulier par les caractères suivants ; taille plus petite (1-1.5 mm.), tête nettement creusée sur le vertex, ailes tout à fait hyalines. Il semble y avoir aussi une différence biologique entre ces deux espèces, car, d'après Marchal, *I. piricola* paraît en avril et n'a qu'une génération annuelle, tandis que les *I. boscii* ont été obtenus aux dates suivantes : 16.vii. (3♀), 1.viii. (2♀), 11.viii. (3♀), 13.viii. (2♀).

### 2. *Misocyclops marchali*, Kieff.

Les *Misocyclops* ne diffèrent des *Platygaster* que par la forme de l'abdomen, qui est, chez les femelles, allongé et pointu, avec les deux derniers segments plus longs que larges. Ce caractère se retrouve chez les *Prosactogaster*, mais chez ceux-ci, comme chez les *Polygnotus*, les palpes labiaux sont ovales, allongés, au lieu d'être courts et arrondis. Les individus que nous avons sous les yeux correspondent exactement à la description du *M. marchali* de Kieffer, autant par la forme des antennes et de la tête que par la présence de sillons parapsidaux complets, de stries transversales sur le vertex, et de striations longitudinales sur le 1er segment et la partie antérieure médiane du 2me segment abdominal.

Les *Platygaster* et les *Misocyclops* sont parasites de Cécidomyides et en particulier de diverses espèces de *Perrisia*. *M. marchali* avait été obtenu à Paris des larves de *Perrisia ulmariae*, Bremi, sur *Spiraea ulmaria*. De *Perrisia pyri* sont éclos environ 40 individus les 16. vii., 7 et 8. viii., et surtout les 11 et 13. viii. Tous les individus examinés étaient des femelles.

## Fam. DIAPRIIDAE.

### 3. *Trichopria* (*Planopria*) sp.

Un seul mâle, éclos le 1.viii. et qu'il ne nous est pas possible de déterminer plus exactement, rentre dans ce sous-genre par la forme de ses antennes aux longs cils réguliers, disposés en verticilles. Les Diapriides étant en général parasites de petits Diptères Brachycères, ce mâle n'était probablement pas parasite de *Perrisia*.

## Fam. CHALCIDIDAE.

### 4. *Torymus abbreviatus*, Boh.

Cette espèce semble être un parasite important de la Cécidomyie, car, d'après les étiquettes, les éclosions se sont succédées très régulièrement entre le 30 juillet et le

17 août, et ont donné 23 femelles et 6 mâles. Mayr (1874) a publié une bonne description de ce *Torymus* très variable de taille et de teinte, qu'il a obtenu de la *Cecidomyia rosae* (= *Perrisia rosarum*, Hardy). Marchal (1900) l'a obtenu en France de la *Perrisia persicariae*, L., sur *Polygonum amphibium*, et de la *Perrisia pyri*.

### 5. *Eurytoma aciculata*, Ratz.

Nous rapportons à cette espèce une seule femelle, éclos le 1.viii.; elle correspond bien aux descriptions de Ratzeburg et Mayr, qui ont obtenu cet *Eurytoma* des galles de saules faites par les *Pontania* spp. et par des Cécidomyides.

### 6. *Tetrastichus brevicornis*, Nees.

Un seul mâle, éclos le 30.vii. Cette espèce est généralement parasite dans les galles de Cécidomyides. De Gaulle indique comme hôtes les genres *Cecidomyia*, *Lasioptera*, ainsi que *Agromyza* et *Rhodites*; Marchal l'a obtenu des larves de *Perrisia oenophila*; et nous avons dans notre collection des exemplaires éclos de *Rhabdophaga rosaria* (Berne) et de *Cystiphora sonchi* (Vienne, Isère).

### 7. *Entedon* sp.

Trois exemplaires, 1♀ et 2♂, éclos de 11.viii. Il ne nous est pas possible de déterminer plus exactement cette espèce, les nombreux Entedonides étant difficiles à identifier. Peut-être s'agit-il de l'*Entedon metallicus*, Nees, qui a été obtenu de *Mayetiola poae* et de *Rhabdophaga rosaria*.

Fam. BRACONIDAE.

### 8. *Apanteles longicaudis*, Wesm. 2 ♀.

### 9. *Apanteles xanthostigmus*, Hal. 1 ♀.

### 10. *Meteorus ictericus*, Nees. 1 ♀.

Ces trois Braconides, éclos vers la fin de juillet, sont des parasites de Lépidoptères et sont probablement sortis de quelques petites chenilles des feuilles de poiriers. Ce sont des espèces assez répandues qui parasitent toutes sortes d'espèces de Micro-lépidoptères. Ils n'ont donc aucun rapport avec les *Perrisia pyri*.

## EXPERIMENTS IN THE CONTROL OF TSETSE-FLY.

(Report of the Tsetse Investigators in N. Nigeria.)

By LL. LLOYD, D.Sc.; W. B. JOHNSON, M.B., B.S., F.R.C.S.; and  
P. H. RAWSON, M.C., M.R.C.S., L.R.C.P.

(PLATES XXXVI—XXXVII.)

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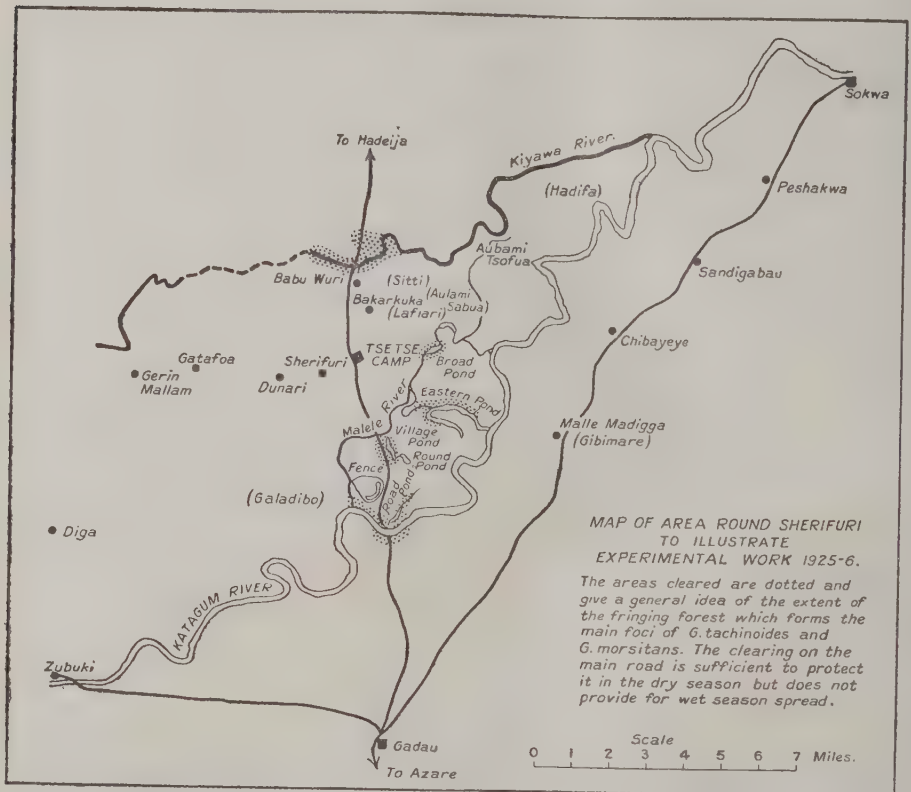
**1. Introduction.**

The Second Report of this Investigation (1) gave an account of the work up to the end of January 1924. The present report is a continuation of the second in which certain points in the routine work are more fully dealt with. The trypanosome infections of the flies to which frequent reference is made were described in detail in interim reports (2, 3). The present account carries the record of the work up to the end of May 1926.

During this time there have been several changes in the working party. Dr. Henry Morrison left the Commission in April 1924, being relieved by Dr. J. W. B. Hanington, who remained till February 1925, being in sole charge for three months while the Entomologist was on leave. The latter was alone for the following seven months, when Dr. F. H. King arrived to take charge of sleeping sickness treatment and remained for six months. Dr. W. B. Johnson, who had returned to his substantive duties at Kaduna during 1924, rejoined the Commission in November 1925, and is now permanently attached to it, while Dr. P. H. Rawson, who has had previous experience of tsetse work in Uganda, joined in the following month.



In September 1925, on instructions from his Excellency the Acting Governor, a local Conference on Tsetse Problems was called together at Kaduna by His Honour the Acting Lieutenant Governor of the Northern Provinces, the Heads of various Departments, and those Residents who were able to do so, attending. The hearty promises of cooperation in the work then made were very gratifying to the Investigators, and their thanks are due to Mr. Palmer for calling this Conference together and for the general helpful interest he is taking in their work. As an immediate result of this meeting Capt. R. O. Ramage, Assistant District Officer, was appointed in charge of the Katagum Division in order that he might devote a large part of his



time to administrative duties in connection with the Commission, and he resides during the dry season at the Sherifuri Camp. Our thanks are due to him for the survey on which the accompanying map is based and for help in many ways.

The location of the Investigation is at Sherifuri in the Katagum Division and lies one hundred miles due east of Kano. In order to make the following report comprehensive it is necessary to recapitulate briefly the characters of the district and the climate around Sherifuri. The Camp lies midway between and about four miles from the Katagum and Kiyawa Rivers. The former is a broad sandy stream bed, which holds running water usually from June to January and large pools all the year. The Kiyawa is a narrow stream in a deep bed and flows nearly throughout the year, and when it is not flowing its pools are almost continuous. The country is a plain

of black mud with low sand ridges, desert formed. The drainage is sluggish, the rivers having many effluents, and there are numerous forest pools in the black mud. The forest on the sand is mainly deciduous, but there are also patches of heavy primary forest with trees of evergreen type where the sand comes near the pools and on the banks of the meandering rivers, where these are ancient. There is not much thicket on the sand, but this is dense, extensive, and sometimes impenetrable on the river banks and about the pools in proportion to the length of time water lies in them. The mud plain has scanty forest, the baobab bulking largely in it, but it has numerous tamarind trees, which are evergreen and the worst thicket supporters in the district.

The rains normally break about the middle of May after two months of very hot weather with mean temperatures of nearly 90°, and they end with September, the rainfall being 25 to 30 inches, nearly half of which falls in August. The meteorological records are given in Table VI.

Two species of tsetse-flies are present, *Glossina tachinoides*, which prevails along all the water-courses while water is in them, and *G. morsitans*, which is mainly found along the Katagum River and its plains, but at the end of the dry season is much restricted to the forest near water. *G. morsitans* was rarely seen in the neighbourhood of the Kiyawa River, which was populous up to three or four years ago, but has recently (1926) extended its range there in association with the depopulation and consequent increase of game along this stream.

The third species of tsetse common in Northern Nigeria, *G. palpalis*, has not been seen in this locality, but it occurs on both these rivers nearer to their sources and possibly occasionally spreads as far as Sherifuri, since one of us has recently and quite unexpectedly encountered it in similar country near the Duduru Stream on the main Kano-Bornu Road crossing, near the large town of Gaiya, some 35 miles due east of Kano. Gaiya lies more than a hundred miles north of the nearest previously known location of this species in the same longitude, so that *G. palpalis* evidently upon occasion penetrates further into the drier parts of Nigeria than was believed.

Generally in the northern parts of Nigeria the natives have escaped ravaging epidemics of sleeping sickness because the habits of the people did not lend themselves to these. The Hausas have drawn themselves together for defensive purposes into communities so compact that adequate clearings have been maintained around their towns, while the smaller Pagan tribes have withdrawn to high hills where intimate contact with tsetse does not occur. The third large element of the population, the nomad Filani, escapes for a different reason. They are in small communities, but wander with their large herds of cattle and avoid places where the mortality of their stock from tsetse-borne disease is great, and in consequence they themselves escape prolonged intimate contact with the fly. The area around Sherifuri forms one of the exceptions. The people are Kanuri, a farming tribe who live in small communities in towns built entirely of light wood and grass; but though their towns are of such poor construction some of them are long established, having occupied the same sites as far back as local history goes. While these people keep to the higher sand ridges and water from their wells, some sixty feet in depth, they appear to be safe, but their wells though timber-lined usually fall in towards the end of the rains, and it appears to the natives, then fully occupied on the farms, to be simpler to fetch their water from the forest pools till the digging of new wells is forced upon them by the general drying of the country. The women who fetch the water come into daily contact with the fly. Frequently also small communities break off from the larger towns and, tempted by the more fertile ground and the proximity of water, make settlements on the river banks and near the pools; but the hamlets are too small to form adequate clearings, and the result is a body of people living actually in the main range of the fly. The pools in the river-beds and forest, when the water gets low, are fished by driving, large bodies of men and boys being engaged, and at other seasons by means of the fish-traps of the professional fishermen (Pl. xxxvi, fig. 1). Such habits of life in a locality where

tsetse abound afford every opportunity for epidemics of sleeping sickness. How long the disease has been established there is not known, but it is by no means of recent introduction. There is a record of an epidemic of it seventy years ago, and of another thirty years ago, history recording the towns most affected and their resulting movements. The present outbreak of the disease began about seven years since, at a time when the people were particularly prosperous, and has resulted in the number of deserted villages which are shown on the map, and many farms not shown have also been abandoned. Although the disease has certainly been long established, it remains of virulent form, and spontaneous cures such as are known to occur in Southern Nigeria have not come to our notice. As an important trade route traverses the area, these recurrent epidemics are of more than local importance, and apart from the human disease, the fly area intersects a rich cattle country, forming a belt that cattle do not traverse, and cuts them off from the best grazing and water in the dry season. Such bars cause the great annual treks that the herdsmen make in search of grazing, and these are a fruitful means of spreading other diseases of stock, and quite apart from this they are objectionable from the point of view of the Political Officers. It seems impossible to stop them unless the better watered parts of the north can be made safe for cattle in the dry season.

We are attempting to free this trade route from tsetse by means of clearing and at the same time continuing other experimental field work.

## 2. Description of Tsetse Foci.

Apart from the two main rivers the following localities, which are shown on the map, have been utilised in the experimental work.

(i.) The Road Pond or Ruan Baraye (Thieves' Water) is a pool about a mile in length abutting on the main road, an old resort of brigands who raided caravans passing to and from Hadeija. It contains water for the greater part of the year, and in some seasons does not dry up entirely. A patch of heavy forest lies to the north-west of it infested with *morsitans*, and both species of tsetse prevail about it for the greater part of the year and are always to be found there, though in very small numbers at the end of the dry season. It was fenced round, as the map shows, and game was excluded from it in the dry season 1924-5. Contrasting photographs taken at the beginning and at the end of the dry season are shown in Plate xxxvii and may be taken as typical of these smaller pools.

(ii.) The Village Pond (Tabkin Dumugu) and the Round Pond (Tabkin Kewaya) are similar pools in proximity with patches of heavy forest in their neighbourhood. Both of them dry up in the middle of the dry season, and *tachinoides* disappears from them soon afterwards, but *morsitans*, as in the last case, is always to be found there. Together they formed the best parallel to be had as a control area for estimating the effect on *morsitans* of fencing in the Road Pond, and first the Village Pond and later the Round Pond was so used. The conditions about the two were closely similar as regards forest, game, and tsetse, and the inclusion of both as control areas was necessary, because it was found advisable to clear the forest about the Village Pond, and its extension across the main road in the rains of 1925 for the benefit of the remnant of the population of Dumugu's Village and of passing traders, to whom this patch of fly was such a serious menace.

(iii.) The Eastern Pond (Tabkin Gabas), shown in Plate xxxvi, is a large permanent sheet of water in a depression that was once the river-bed and is still an effluent in the rains. It had heavy ancient forest on its high northern bank, and this was cleared in the dry season 1925-6. Its riverward bank is a long-grassed plain with thin recent forest. *G. tachinoides* and *morsitans* were very prevalent here throughout the year, and like the Katagum River, it is a primary focus of both species, and its fly is always continuous with that of the river bank. An important path connecting the grain market of Gerin Mallam with the towns east of the main river skirts this pool.



(iv.) The Broad Pond (Tabkin Dafadi) is a depression on the meandering Malele River, an affluent of the main stream. Its nature is similar to that of the Village Pond, and it was a secondary focus of *morsitans* and *tachinoides*. It is crossed by an important path, and recently there were near it extensive farms deserted in 1922. It was cleared in the dry season 1925-6.

### 3. The Primary and Secondary Foci of Tsetse.

It is necessary to get some exact understanding of these terms, which were first proposed for *morsitans* by Shircore (4). His conception seems to have been that at the end of the rains the fly was pretty generally distributed over its range, but as the dry season advanced and the forest away from the neighbourhood of moist ground became more and more shadeless, colonies of fly were marooned in certain spots (secondary foci), where they did not persist till the following rains, but the places were repopulated from those spots (primary foci) where the fly had persisted.

To extend this conception the fly area in the dry season may be likened to a desert in which there are a number of oases of varying degrees of permanence, while the flies inhabiting the area are like the nomad population of such a desert, having in the permanent oases large settlements that constantly tend to outgrow their food supply and in the temporary oases smaller settlements with many travellers. In the permanent oases it must be imagined that the population is so great that an influx of travellers is inappreciable, but in the smaller ones the casual variation in the number of visitors results in an appreciably varying population. Similarly in the primary fly focus under constant weather conditions from week to week no appreciably varying density of fly is found, but in a secondary focus that is becoming unattractive there is a visibly varying fly population. Thus, for instance, at one secondary *morsitans* focus (Road Pond) in April and May under constant weather conditions, the varying density expressed as the number of flies caught per boy-hour in seven successive weeks was 36, 24, 14, 43, 22, 32, 17. Again, at an oasis when the water has dried residents disappear, but tentative visitors still arrive and finding no water may linger in the remaining shade for a time, and then die or pass on; so in the secondary focus, when there is no water and animals become few, travelling *morsitans* will



young of *tachinoides*, ranging more along the water's edge and the glades of the thicket, do not make these bold flights. The point is more fully dealt with later in the report.

#### 4. Description of Routine.

Previous to and parallel with the experiments, routine dissection of tsetse has been carried on in order to obtain an estimate of the effects of changed conditions. Flies have been examined week by week from several of the fixed points mentioned above over a period of three and a half years, with the exception of one month (September 1925) when the camp was closed. The statistics accumulated are shown in Tables I—V and Charts I—XIII for those foci that were affected by experiment. In all, 26,625 *morsitans* and 26,639 *tachinoides* have been dissected at Sherifuri, and for statistical purposes the findings are divided into 283 monthly groups of flies according to the foci from which they were derived. The figures are mainly given in percentages of the monthly groups, and the average number on which these are based is 188. When flies become very scarce at a focus it is not always possible on the days allotted to it to obtain sufficient insects on which to base a reliable percentage, and for this reason nine of the groups recorded are composed of less than one hundred flies and, of these, two are below fifty, which is certainly an inadequate number. These less reliable figures are marked by asterisks in the tables. The figures that seem to mark the culminating point of a rise are emphasised by heavy type, and those that are believed to be affected by experiment are placed in brackets.

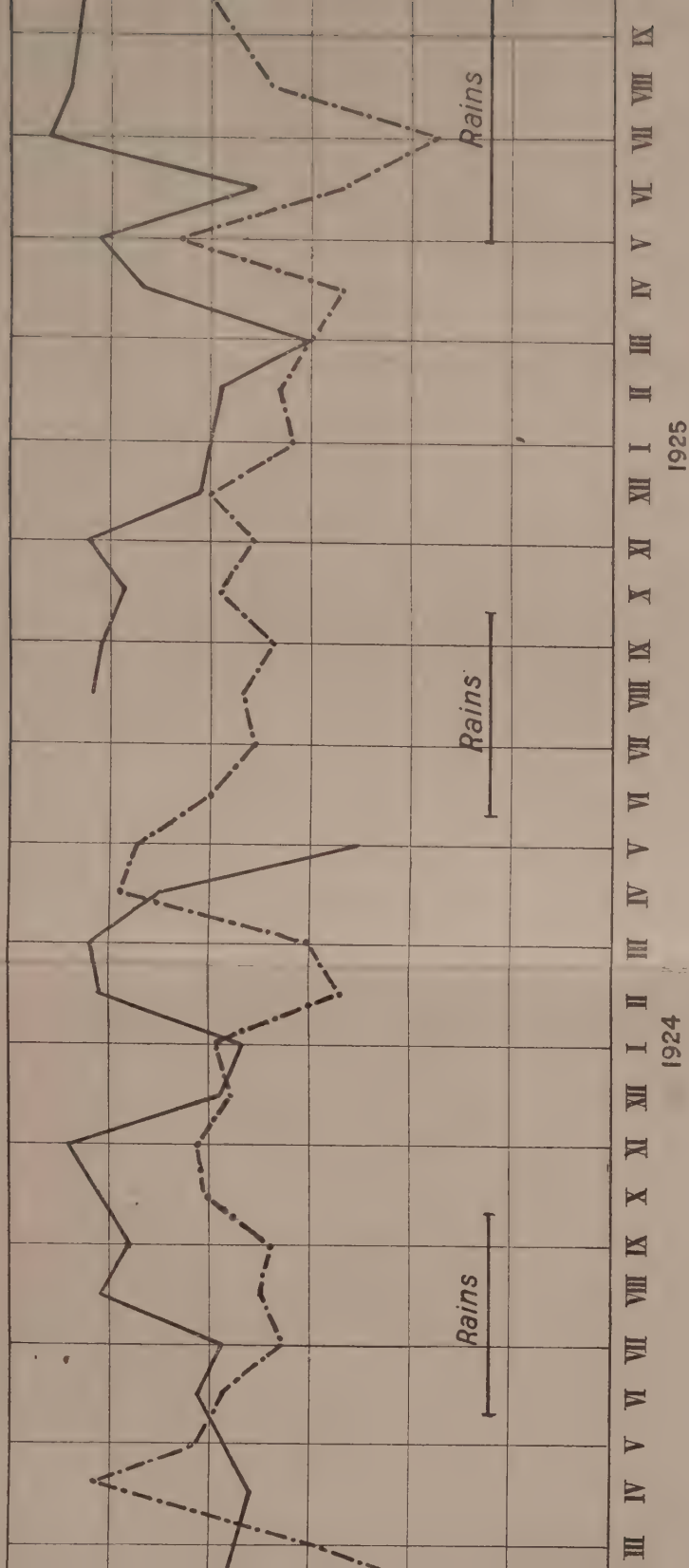
In recording statistical work of this type some irregularity of the curves must be expected on account of unknown or inexact known factors. The only influencing factor that can be recorded with any exactness is seasonal change, with its resulting effects on vegetation and prevalence of water, and these in their turn affect the flies directly and indirectly through the seasonal movements of the animals that form their food supply. Animal movement varies greatly from year to year in a manner that may be in no way connected with seasonal change and in the case of the antelope may be profoundly affected by the erratic movement of the beasts of prey. For instance, a lioness may particularly haunt one spot when she has cubs, with the result that game avoids the vicinity. In the dry season 1924–5 a lion established itself a little above the ford of the Katagum River and drove away a herd of some thirty roan that watered there, with the result that in December they were watering regularly at the Road Pond, and when this was enclosed they passed it each night and watered at the Village Pond till its water dried up; in the next dry season no sign of this herd was seen. Such a change, when known, may be seen to affect the figures, but there are many similar changes about which one knows little or nothing. Such variable factors make the tsetse a particularly difficult insect to study statistically. Nevertheless, though at first sight irregularity appears to be the keynote of the curves reproduced, there is shown among them a quite definite rhythm that can be accounted for by change of season and its resulting effect on the flies through their food supply, and this helps to a better comprehension of the bionomics of the flies and forms some sort of a basis on which to estimate the effect of experiment.

The following notes are relative to the routine and the seasonal changes which have been noted.

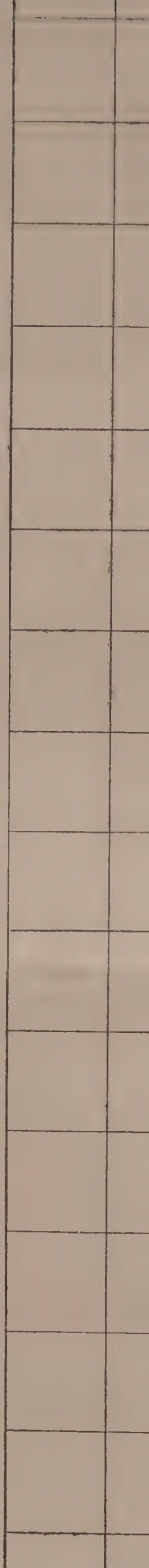
##### (a). Female Percentage (Tables I—V, section (a); Charts I and II).

The record of the proportion of the sexes in the catch has been kept for the whole period at Sherifuri. With *tachinoides* there is a difference in the behaviour of the flies at the primary and secondary foci. At the former the proportion of females reaches a high point in the earlier part of the dry season and, after an annual fall associated with the mid dry season, rises to a maximum of nearly 50 per cent. in April–May, just before the onset of the rains and again falls towards their close. At the secondary

I. Seasonal Fluctuations of Female Percentage in Catches of *G. tachinoides*.



II. Seasonal Fluctuations of Female Percentage in Catches of *G. morsitans*.





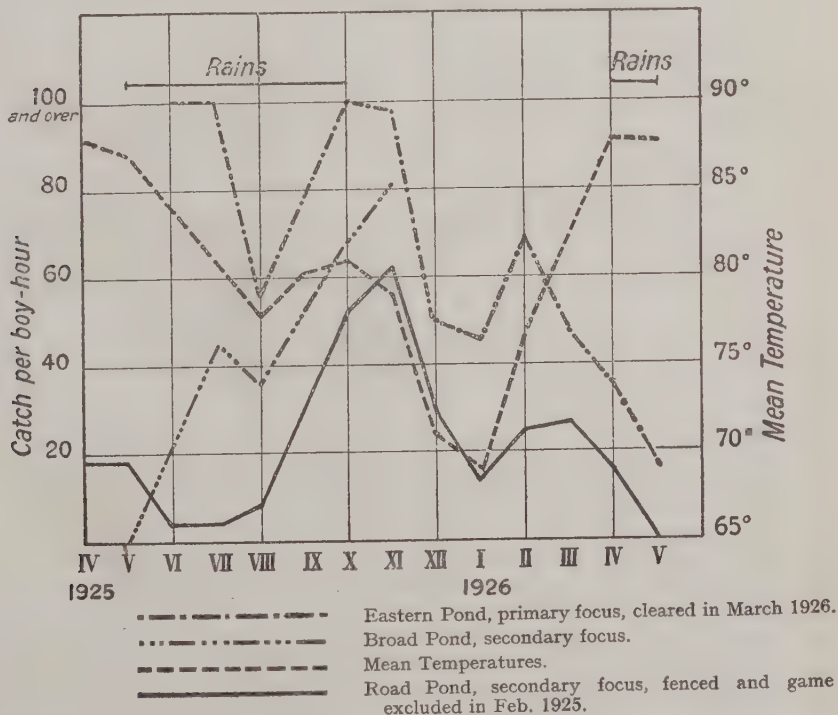
foci during the dry season the proportion of females is erratic, but at each of them from which flies have been examined the proportion rises in the heavy rains, when recolonisation is most active, to over 50 per cent. and once through a month at the Broad Pond to 81 per cent. of the catch. As the sexes are bred in equal numbers, it may be taken that any number above 50 per cent. means a real excess of females over males at the spot, while below that point variations are no doubt connected with the food supply, as in the case of *morsitans*, though one cannot associate them with any special elements of the wild fauna. It would therefore seem that the high proportion of females at the secondary foci, when it is relatively low at the primary, means that the females play a larger part than the males in the early wet season spread.

With *morsitans* at the primary foci the female percentage rises to a maximum (usually about 20 per cent.) at the end of the rains, when the antelope are most dispersed, and is low as a rule in the dry season, when they are concentrated. In the secondary foci also the high proportion in October is found, but there is also a definite rise towards the end of the dry season when the small pools dry up and the antelope are specially scarce there, and still a third annual rise appears to be the rule about July, when recolonisation of these centres is becoming active.

(b). *Rate of Catching* (Tables I—V, section (b) ; Charts III and IV).

This factor, which we express as the number of flies male and female that a fly boy catches in an hour with a net, is apt to be rather indicative of the activity of the insects when the collection is made than of their actual numbers. The catches are profoundly affected by the weather and the time of day when the flies are caught.

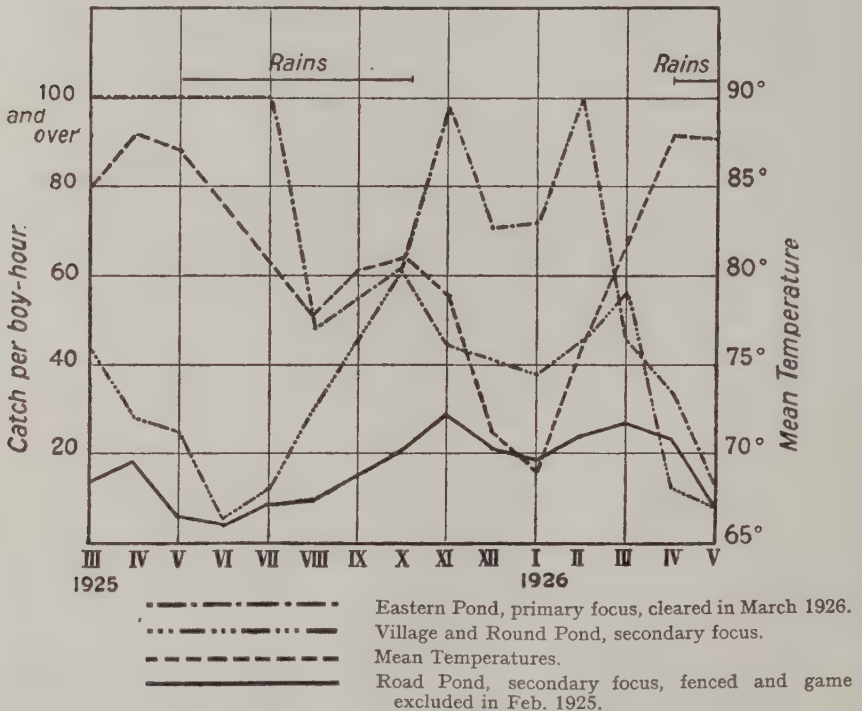
CHART III. Rate of Catching *G. tachinoides* (Density+Activity).





Almost invariably in this case the catches have been made in the mornings, starting when the sun has been up two or three hours. During the harmattan months (December to February particularly) there are many days when the sun has little power owing to the dense haze, and on these the flies are inactive, though they are really numerous then at all foci. The figures for a complete year at a primary focus are therefore to be taken rather as representing the relative activity of the flies at different seasons, but those for any one month at the various localities may be justly recorded as relative density, though high figures are less comparable than low ones. A skilful boy cannot net and box alive many more than a hundred flies an hour, even though they may be round him in a swarm, and variations from this number upwards

CHART IV. Rate of Catching *G. morsitans* (Density + Activity).



have very little relative meaning. We have only latterly kept a record of these figures, having found it more convenient for the laboratory work to order the boys to bring in a stated number each, when they work harder and are more likely to collect a sufficient number for dissection in reasonable time than if they are told to collect for a certain number of hours. At their own request the method of netting in the shade of umbrellas has been given up, as they say that when tsetse are scarce they can catch more without these encumbrances. In catching *tachinoides* they stand in an open place in a glade under the shade of a tree and catch the flies as they come to their legs, remaining in the same spot perhaps till their quota has been caught. In catching *morsitans* they never remain still for long, but take short rapid walks of some fifty yards along the edge of the thicket and then pause just long enough to collect the flies their short walks have attracted. This quick walk, which is much more rapid

than the ordinary dignified movement of the Hausa youth, has clearly been adopted by them in order to attract the attention of the flies when these are scarce. That it should so attract them is not of course new knowledge, but it is of interest to see them applying it.

The figures recorded for a year show for *tachinoides* at a primary focus (Eastern Pond) a high rate of density and activity at the beginning of the rains (June-July). The sharp fall to 56 in August is mainly due to the fact that then the fly is most dispersed. There is a rise towards the possible maximum catch again in October, when concentration occurs, and a fall with falling temperature to a low figure (46) in January. The numbers begin to recover as the temperature rises and would normally be high again in March, but clearing work at the pool has affected them. The figures recorded for the secondary focus at the Road Pond are much affected by artificial conditions, but show to a less extent the same type of rise and fall from October to March as those at the Eastern Pond.

With *morsitans* at a primary focus there is a high rate of density and activity from February to July, and the rise and fall of the numbers are much as for *tachinoides*, and for the same reason, except that the high point after the rains is a month later, concentration being later. As with *tachinoides*, the figures for March to May 1926 are profoundly affected by clearing. In the fenced area the figures are also much lowered by artificial conditions, but in the secondary focus at the Round Pond they are less affected and show the normal high activity in October and March, with reduction in activity in the cold weather and the real reduction in abundance which characterises the secondary foci from April to June, with real increase from July onwards.

(c). *State of Nutrition* (Tables I—V, section (c) ; Charts V and VI.)

At certain times a proportion of the flies are found to be thinner than normal, the abdomen being flat and wafer-like, while the fat cells are small and often triangular in shape, instead of being large and bloated. A record of these has been kept since August 1924. The curves produced show a regular rhythm for both species when undisturbed by artificial conditions, starving flies rising to a maximum about the time of the heavy rains (August) and falling to a minimum by the middle of the dry season. The fluctuations under normal conditions at Sherifuri are from nothing up to 10–20 per cent. The figures are of considerable value and the estimation forms one of the best indications of the effect of changing conditions.

(d). *Breeding Seasons and Rate of Breeding* (Tables I—V, section (d) ; Charts VII—VIII).

On dissection, some of the flies are found to be very soft, a condition that shows they have emerged from the pupae within the past day or two. The ptilinum can generally be pressed out of the head, and the chitin is not fully pigmented, while the fat cells are small and many of them transparent, coming loose when the abdomen is torn open and sometimes flooding out like pills pouring from a box, in a manner that never occurs in an old fly. The gut contains only a little dark detritus, unless the fly has succeeded in obtaining a meal soon after emergence. The distinction is easy in *morsitans* but not quite so definite in the more fragile *tachinoides*. The record has been kept since November 1923.

In our Second Report we laid some emphasis on the apparent reduction in the rate of breeding in both species during the wet season, basing it on the sudden increase in the proportion of soft flies in the dry season of 1923–4, following on improved nutrition, and our previous experience at Mashiwash, together with the fact that collections of pupae through the dry months shows a steadily increasing proportion of empty pupa-cases. Mashiwash was in a wet zone and had a rainfall of about 50 inches, while in the wet season of 1923 at Sherifuri 36 inches of rain fell. The rainfall of

1924 at Sherifuri was only 24 inches and that of 1925 only 26 inches, with a grave deficiency of rain in June, while the winter (December–February) of 1924–5 was unusually cold (see Table VI.) In this cold winter there was no sudden increase in the proportion of soft flies in either species, and chill has of course a very retarding effect on the pupae. In the wet seasons of 1923 and 1924 *tachinoides*, as evidenced by the proportion of soft flies, was breeding fairly freely about the Eastern Pond, and in the second of these rains actually more freely than in the intervening dry season. With this important exception the figures confirm our belief that *tachinoides* breeds more freely in the dry months than in the wet ones. At the Eastern Pond, the recently emerged *morsitans* were almost uniformly scarce from March 1924 to August 1925, but in the secondary foci they were much more prevalent in the dry season than in the rains, the condition being artificially exaggerated by fencing at the Road Pond. For *morsitans* the restriction of breeding in the rains appears to be confirmed.

Supposing that the female flies were producing larvae at an optimum speed of about one in twelve days and that a young fly is recognisable as such for two days, then the largest proportion of soft flies that could be present should be in the neighbourhood of 8 per cent., provided that they stayed in the foci where they were produced. With *tachinoides* the proportions at any given time during the dry season in primary and secondary foci show no marked difference, so there is no reason to suppose any special migratory tendency of young flies of this species, but the proportion caught often far exceeds 8 per cent., so it must be concluded that they are more readily caught than older flies, probably because they take more risk in endeavouring to get their urgently required first meal. With *morsitans* at a primary focus the proportion very rarely exceeds 8 per cent. (Table I, d; November–December 1925 are an exception and March–May 1926 are under artificial conditions), but at secondary foci this proportion is often much exceeded, though there may be at the time no evidence of hunger in the flies to indicate that the old flies might be leaving or dying.

If an area is becoming unsuited to tsetse and the old flies are either dying or leaving for more suitable spots, the pupae deposited there will go on producing fresh flies for a time, and in this way an undue proportion of soft flies may be present.\* Such a phenomenon should be accompanied by a definitely falling density, and it does occur possibly in this association near the end of the dry season in the secondary foci; for instance, at the Round Pond in May 1925 the rate of catching *morsitans* was 25 per boy-hour, with soft flies 25 per cent., and again in April 1926, at the same focus, rate of catching 12, soft flies 19 per cent. But this does not account for the high proportions often found early in the dry season, when contrasted with the lower ones at the primary foci, for at this time there is no indication of distress at any foci. We conclude from this that with *morsitans* many of the young flies that are caught in the secondary foci do not originate in these, but in the primary foci, and reach the former in their early flights in search of food. This is a theory that may be difficult of proof, but it receives some experimental corroboration, since the distress among *morsitans* that was produced at the Road Pond in 1925–6 was accompanied by a very high rate of soft flies throughout the dry season, when all the evidence was against any rapid rate of breeding there.

(e). *Food* (Tables I–V, sections (e) and (f); Charts IX, X, and XI).

A record of the blood that can be recognised in the flies has been kept from May 1923. In the Second Report some stress was laid on the seasonal variation of the proportion of flies with recognisable blood. This variation is evidently of annual

\* The best instance of this was afforded when the bank of the Eastern Pond was cleared in March–May 1926. The proportion of young *morsitans* rose from 1 per cent. in February to 13 per cent., 27 per cent. and 16 per cent., in March, April and May respectively, because the focus was being made unsuitable for tsetse and the old flies were leaving. The pupae remained sheltered by the mass of cut vegetation and the flies emerging therefrom caused the abnormal condition.



occurrence with *tachinoides*, as at the Eastern Pond there has been a regular rise in the later part of the dry season (April or May), when the proportion of mammal blood in the flies is high (May 1926 is an artificial exception), and a second rise in the early dry season (October or November) when the proportion of reptile blood is high. Generally a high rate of trypanosome infection follows the former rise and a low rate the latter. At the secondary focus the same rises in the proportion of recognisable blood occurred (except in October 1925 at the Road Pond), but in each instance these were associated with a high proportion of reptile blood. With *morsians* the proportion of recognisable blood has not shown in subsequent years the definite seasonal rhythm that it showed in the first year. We can only say of them that blood is generally scarcer in the later rains (August to September) than at other times of the year. It would seem that the better marked variation in 1923 was due to the unusual rainfall, which caused great inundation in July and August, that drove the game to the higher ground. In the two following years with scanty rainfall the inundations have been less. Alterations in conditions, however, at the Eastern Pond have made material changes in the blood supply, which will be referred to later.

A record of the type of blood in the flies has been kept, whether reptilian, avian or mammalian. In the diet of *tachinoides* the proportion of non-mammalian blood, an overwhelming proportion of which is reptilian, shows a seasonal fluctuation, which is well marked in the primary focus, the maximum being each year in November and the minimum in April, 1926 being an artificial exception. At the Road Pond the same thing occurred in 1923-4, but thereafter conditions are artificial. The maximum point occurs when the amphibious reptiles (mainly the monitor lizards) concentrate at the pools from the outlying swampy ground, but before the game concentrates. Clearly *tachinoides* takes whatever blood is to hand, whether mammal or reptile. With *morsians* non-mammalian blood, always avian, is seldom taken under normal conditions, though more frequently in the rains than in the dry season.

Among the mammalian bloods a further grouping has been attempted. The size of the red cells varies in different mammals, so that they can be divided into five classes according to differences of  $1\mu$  in diameter. The smallest group (2.5-3.5 $\mu$ ) includes goats and sheep, the second the larger antelope and cattle, the third the smaller antelope, the fourth the pig and the donkey, and the fifth and largest (6.5-7.5 $\mu$ ) includes man, monkey and dog. As some small animal or other from which blood might possibly be derived falls into each group, the method of estimation is open to criticism, but it is believed to be substantially correct. The largest blood cells crenate in digestion, while the smaller ones collapse and become sickle-shaped, and this character, but especially the size, enables an experienced worker to pick out in fresh preparations the class that includes human blood from the others without recourse to staining and measurement. This has been the practice latterly when the conduct of field experiments left us little time for laboratory work. There is some confirmation that the method is of considerable value. In the three foci from which *morsians* has been examined, one, the Road Pond, is almost on a main road; the second, the Village and Round Ponds, is a little back from it; the third, the Eastern Pond, is moderately secluded. In the period before conditions were changed by experiment, at the first point named the proportion of the fifth group of bloods examined from the flies was 12.4 per cent. (40 in 312), at the second it was 10.7 per cent. (40 in 375), and at the third it was 6.1 per cent. (28 in 461). The fencing of the Road Pond



group as "blood of human type" with the general assumption that it was mainly derived from man.\*

(f). *Trypanosome Infections* (Tables I-V, section (g); Charts XII and XIII).

Four species of tsetse-borne pathogenic trypanosomes occur in this area, viz., *Trypanosoma gambiense*, *T. brucei*, *T. congolense* and *T. vivax*. The differential characters of these in the fly have been described by us (2, 3). Our method of dissection reveals all mature infections of these organisms and most of the immature infections of *T. vivax*, but not all the immature infections of the other forms, as these in their first phase of development in the fly are confined to the gut. The total of the infections noted in the proboscis and salivary glands will be given as percentages of the number of flies examined and will be referred to as "the infection." Very definite variations in the rate of infection are found at different foci and there is also a well marked seasonal fluctuation.

In the case of *tachinoides* at its primary foci (Katagum River and Eastern Pond), where game is more prevalent, the infection rises about the middle of the dry season from below 10 per cent. to 11-18 per cent., with a fall beginning about August in the late rains. This high rate of infection follows the period of game concentration in the more secluded bush, and during this time the proportion of mammalian blood taken by the flies is high. The Kiyawa River is also to be regarded as a primary focus, since *tachinoides* is always to be had there, but it differs from the other primary foci in that game is scarce and reptile blood all the year bulks largely in the diet of the flies. Here during 1923, in 2,140 flies examined, infections were found in only 18 (0.9 per cent.), and in consequence no seasonal fluctuation could be detected. In the secondary foci of the area the seasonal fluctuation is more pronounced. Thus about the Road, Village and Broad Ponds, the rate of infection is very low from December to May and suddenly jumps to over 20 per cent. in August, with a fall beginning in the following month. (The erratic point in March 1926 at the Road Pond, when the infection suddenly rose to 16 per cent., will be referred to later.) These low rates of infection during the dry season are easily explained, since, as at the Kiyawa River, a large proportion of the flies' food during this period is derived from reptiles. The sudden rise coincides with the wet season spread of the fly from the primary foci, but we have not yet found any satisfactory explanation of the fact that the spreading fly is more heavily infected than that which is found at the spots from which it comes. It has been so in each of three years at all the secondary foci that have been tested.

With *morsitans* there is a general tendency for the rate of infection to rise rapidly in the earlier part of the dry season towards 50 per cent. in the primary focus and to fall in the later dry months. There is a second annual rise after the rains have started and a second fall in the late rains. In the secondary foci the rise in the earlier part of the dry season, though generally present, is less pronounced, but the fall to a minimum rate of infection from March to May is quite well marked. Seasonal variations in the type of blood taken are insufficient to account for the variation, since the proportion of antelope blood, from which the vast majority of the infections is certainly derived, shows only a slight seasonal change. It is probably connected with the age of the flies, since the proportion of recognisably young flies at a secondary focus in the dry season is much higher than at a primary focus in the case of *morsitans* (but not *tachinoides*), and these have had little or no opportunity of acquiring infection.†

\* Some preliminary work with precipitin tests on the blood found in the flies has been carried out recently, and so far as it has gone it has confirmed us in our belief that the great majority of what we call "blood of human type" is really derived from man.

† Recently established infections of *T. vivax* only would be discoverable in young flies, for though very careful examination of the labial cavity does reveal the isolated trypanosomes which are taken up in the blood and become the nuclei of the flagellate colonies, it is not possible in rapid routine work to devote to each specimen the time necessary to locate them, and usually it is only when the infections are four or five days old and small colonies have been formed that they are detected. For this reason, when a collection of flies contains a large proportion of young flies the rate of infection is necessarily lowered.

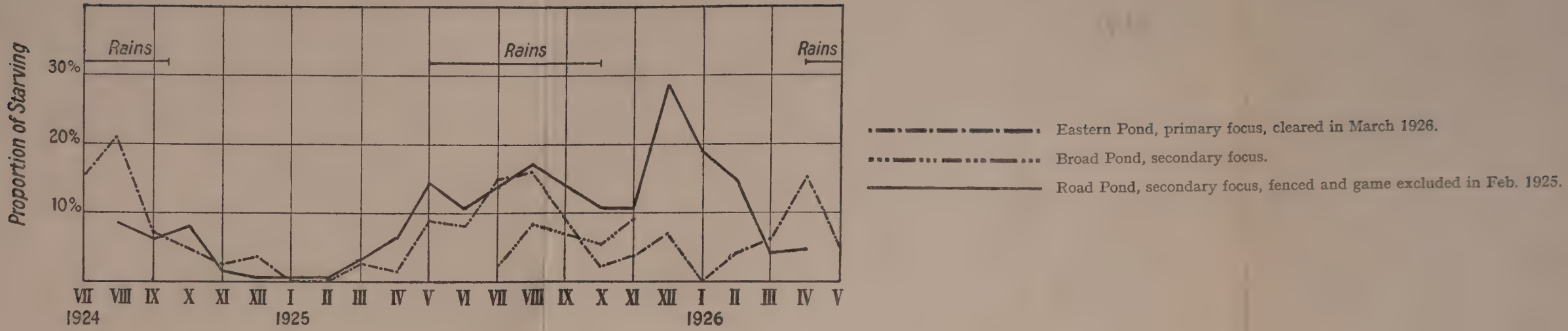
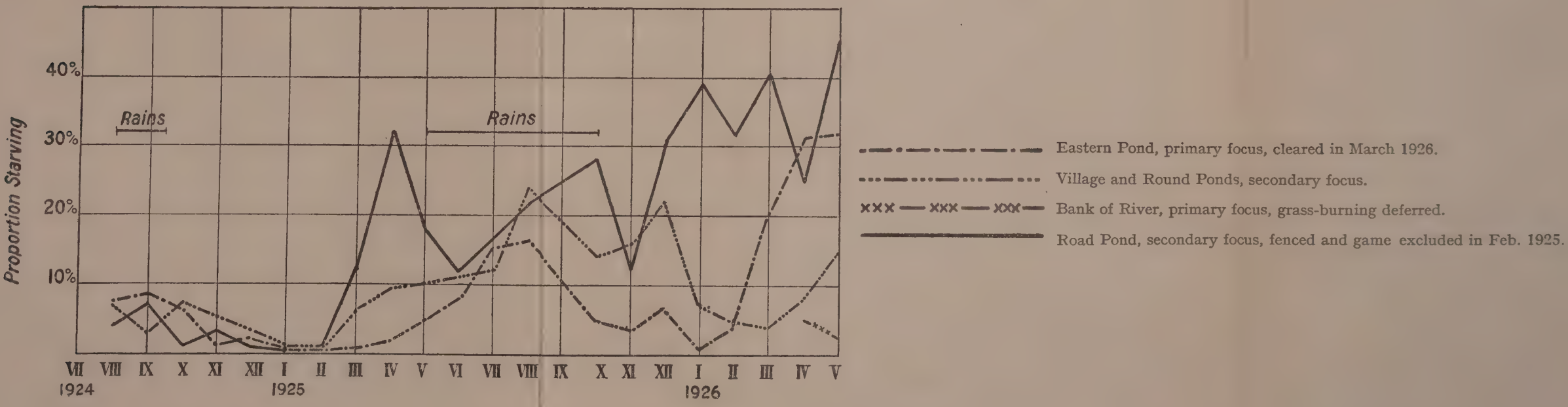


CHART VI. Seasonal Fluctuation of Starving *G. morsitans*.



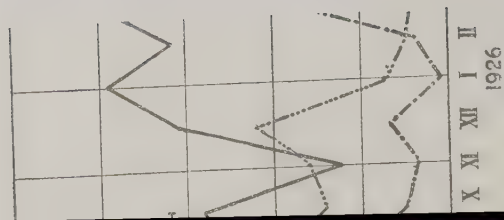


CHART V. Seasonal Fluctuation of Starving *G. tachinoides*.

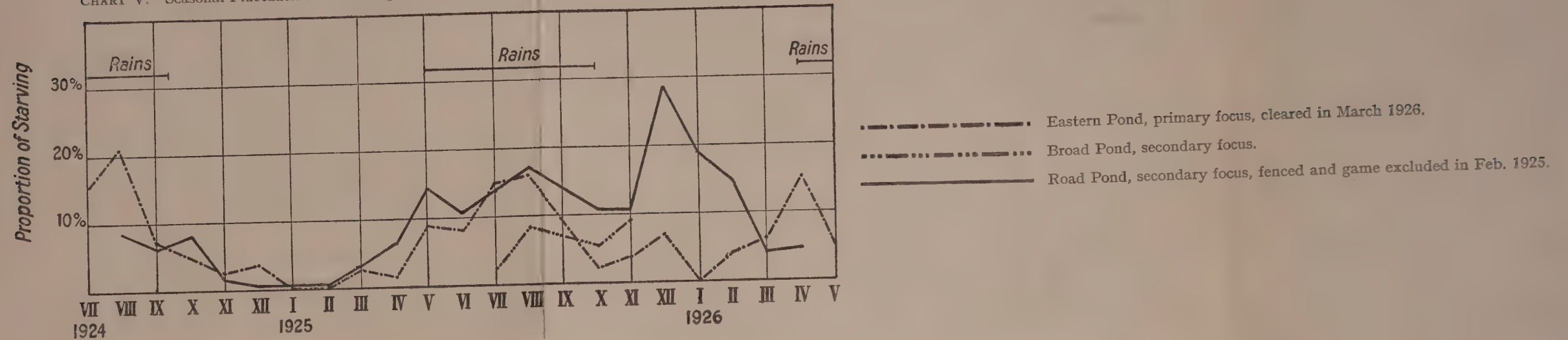
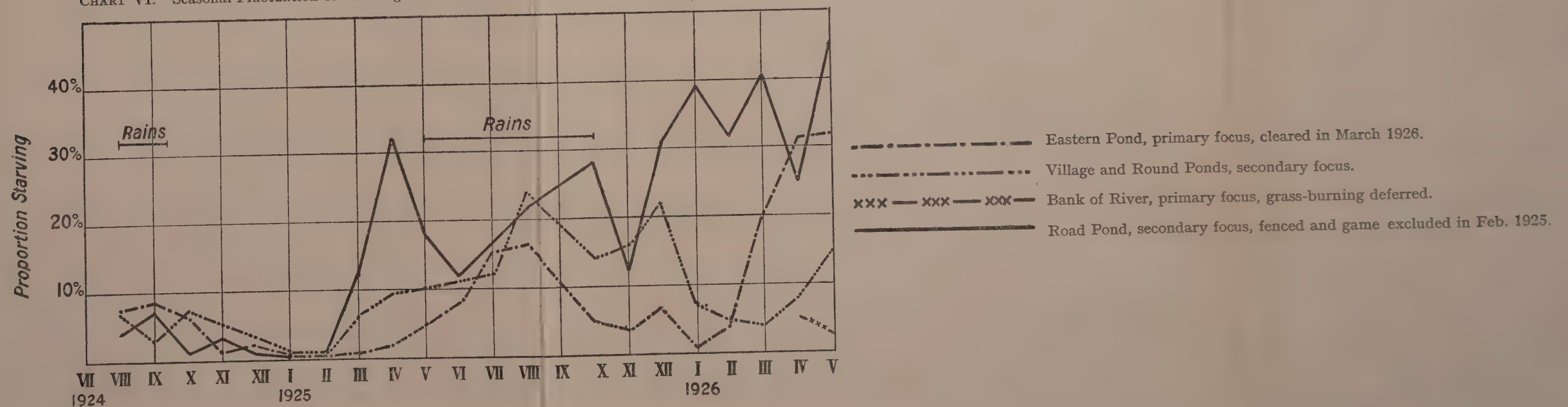


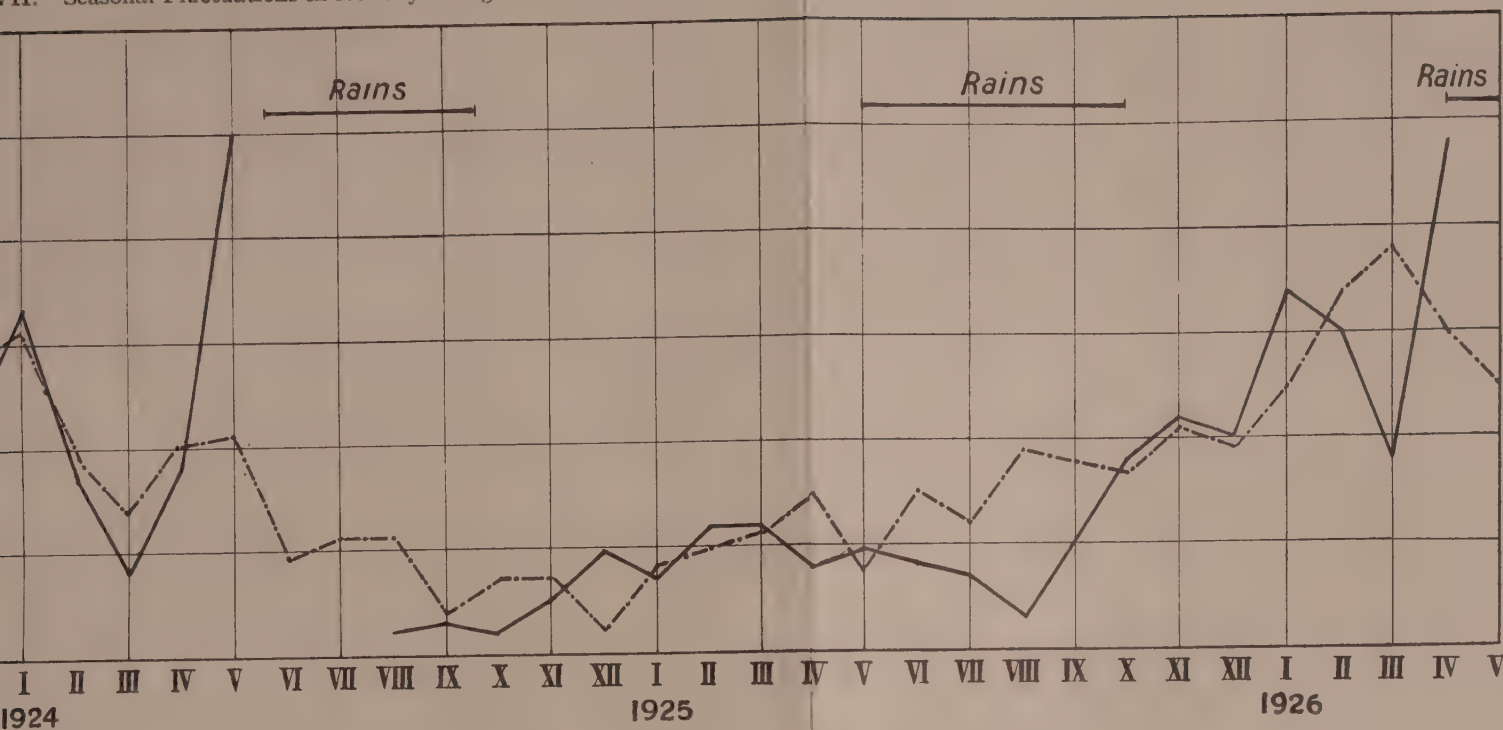
CHART VI. Seasonal Fluctuation of Starving *G. morsitans*.







VII. Seasonal Fluctuations in recently emerged *G. tachinoides*.



VIII. Seasonal Fluctuations in recently emerged *G. morsitans*.

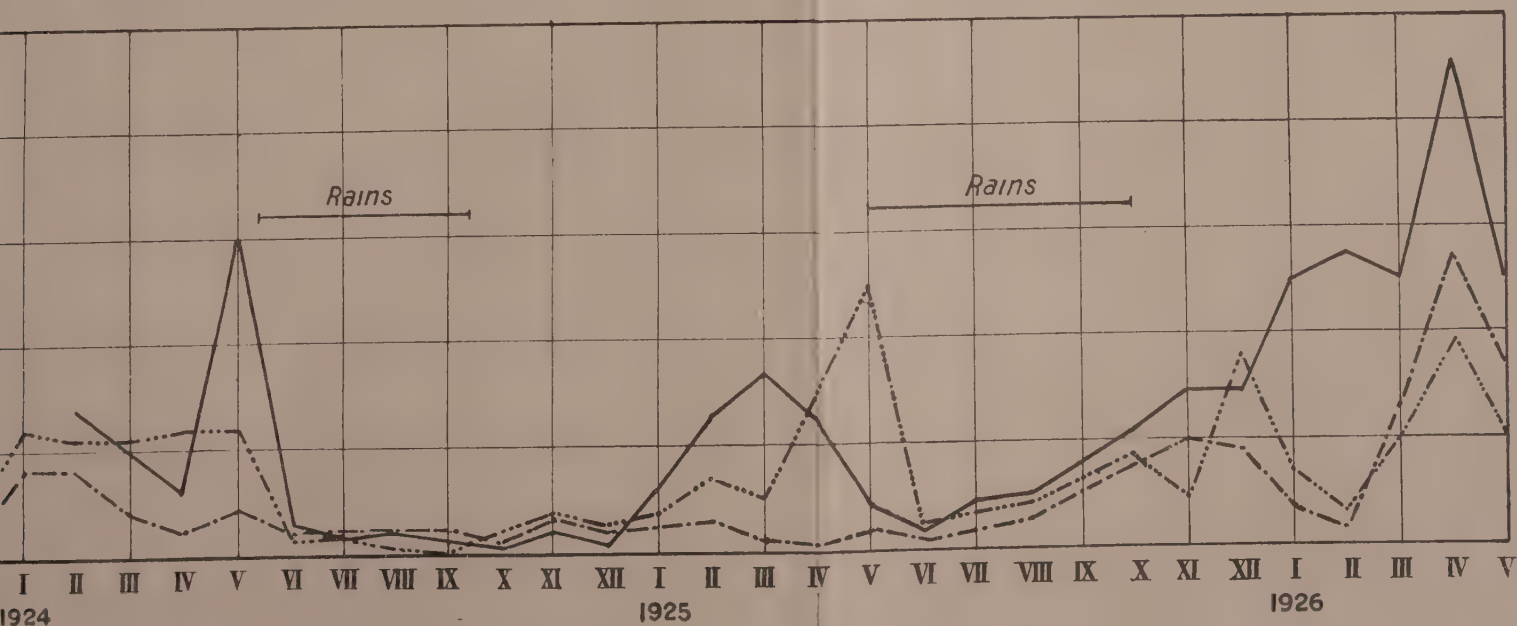




CHART IX. Seasonal Fluctuations of Food of *G. tachinoides*.

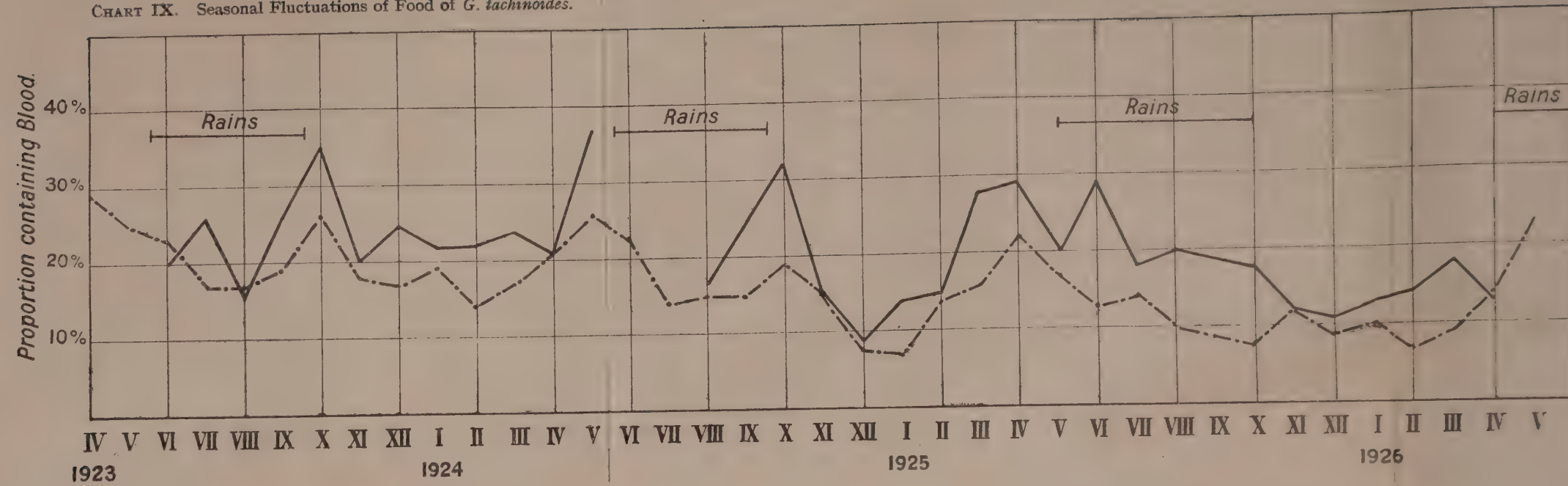


CHART X. Fluctuations in Proportions of Non-mammalian Blood in Diet of *G. tachinoides*.

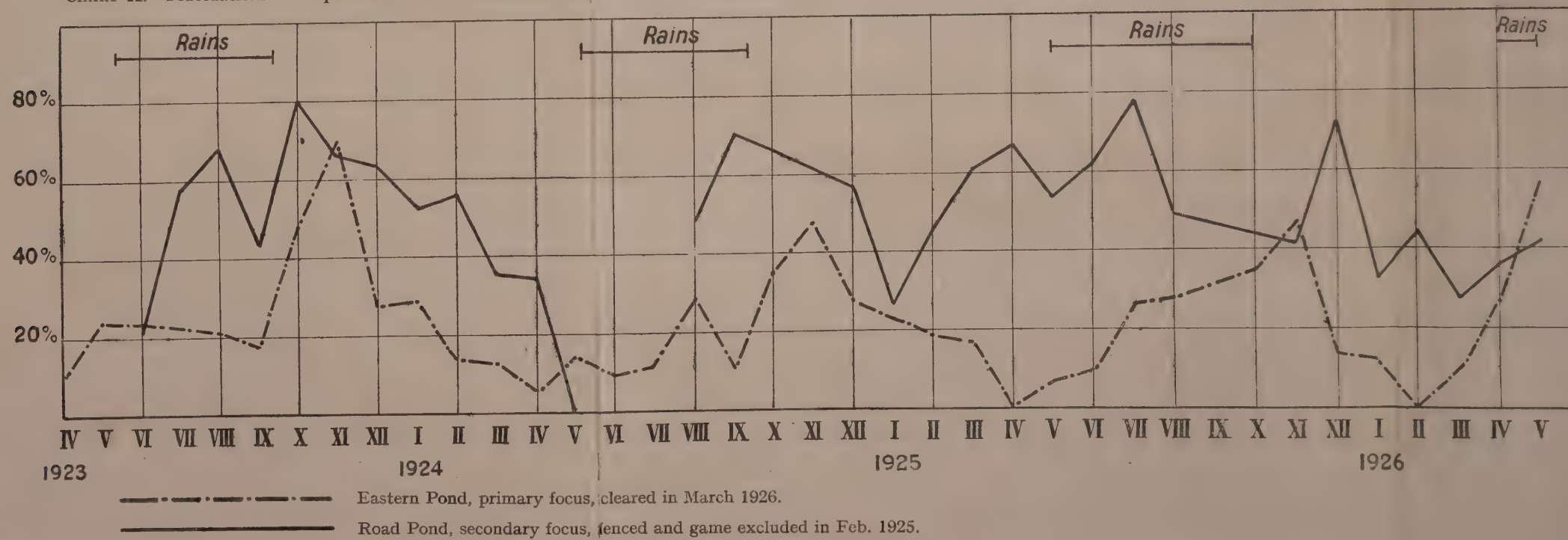






CHART XI. Seasonal Fluctuations of Food of *G. morsitans*.

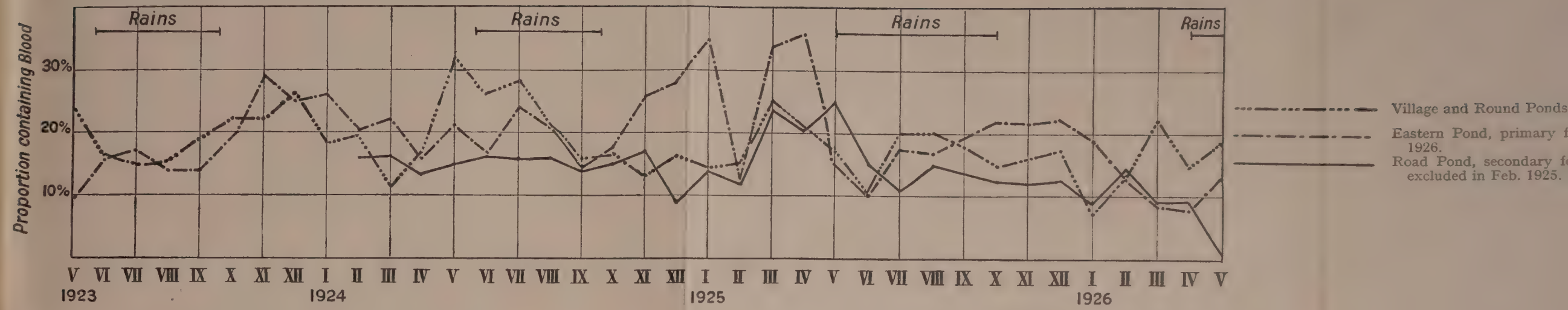
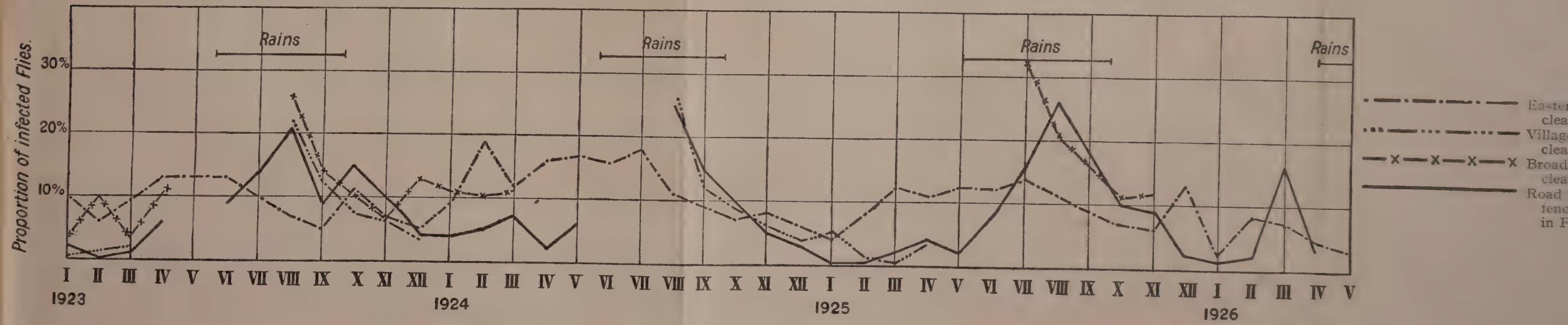
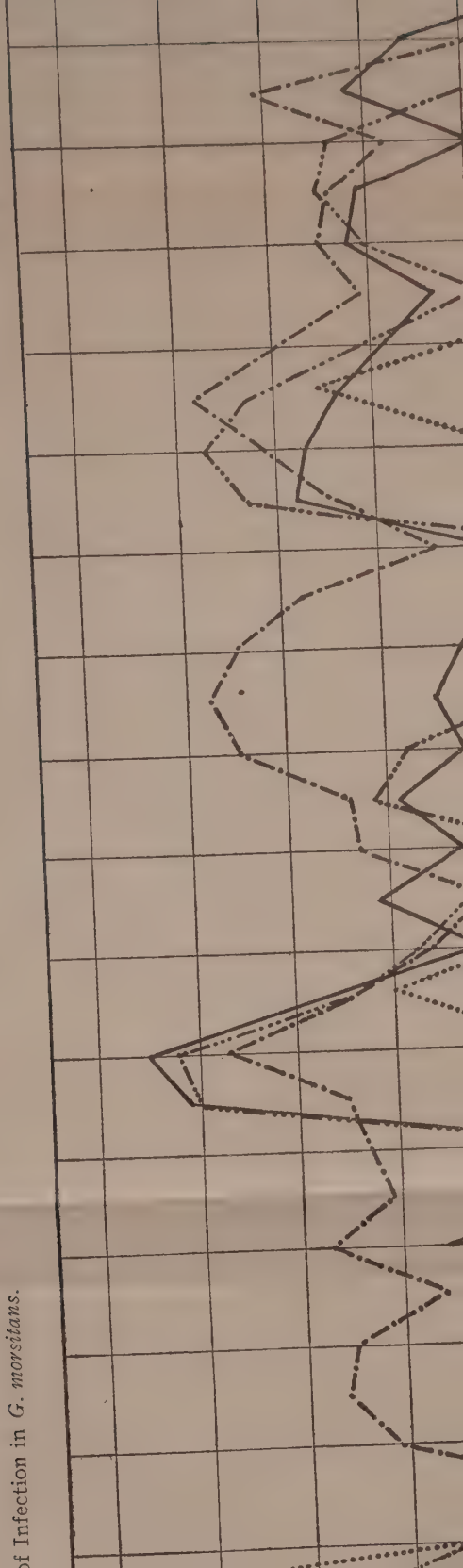


CHART XII. Seasonal Fluctuations of Infection in *G. tachinoides*.





of Infection in *G. morsitans*.







As with *tachinoides*, the rise of infection of *morsitans* at the secondary foci, which accompanies the wet season dispersal from primary foci, is striking, the increase in a few weeks may be from as low as 8-9 per cent. to over 50 per cent. of the flies infected, and again the infection at the secondary foci at this time generally surpasses that in the primary focus.

## 5. Exclusion of Game from a Tsetse Focus.

### i. Description of Experiment.

The question of the advisability of game destruction in connection with the control of *G. morsitans* has long been a subject of controversy. The Committee appointed by the Colonial Office in 1913 to consider tsetse problems discussed a proposal to enclose a tract of country about a hundred square miles in extent by a forty mile fence and exclude from it the wild *Urgulata*, in order to obtain indications of what would be the effect on *morsitans* of game destruction. It was obvious that the cost of such an experiment would be considerable and its organisation difficult, while it was uncertain that it would afford definite guidance for a future policy as regards the game. The war intervening, nothing was then done.

An experiment of this type has now been carried out at Sherifuri, though not on the scale originally suggested, as this would have been beyond the scope of the funds and organisation of the Investigation. We intended at first to fence round the pool known as the Eastern Pond, but it was found impracticable to enclose an area that included so large a stretch of water, owing to the great inundations which would have submerged portions of the fence for several months of the year. In any fencing scheme this would be a difficulty that would alone in most areas preclude the enclosure of any considerable tract of country, since the inclusion of some type of watercourse would be essential. We therefore had to select a smaller pool, and chose that known as the Road Pond as being the most suitable in the district, and together with the surrounding half square-mile of country it was enclosed by a wire fence three miles in length.

The pool is a mile long and of crescent shape, averaging about twenty yards in breadth. It is fed partly by the water that collects on the mud plain to the east and partly by a broad overflow of the Katagum River when this is in flood. When the river falls within its banks, the pool is isolated and dries slowly through the dry season, in most years becoming completely dry by the end of April but sometimes still holding a little water when the rains break. Its banks are topped by a dense thorn thicket, broken in places and varying from a few feet to twenty yards in width. Beyond this thicket to the east and north is an extensive black mud plain, almost shadeless in the dry season, and to the west there is a patch of sand that carries a heavy open forest, which thins off again to the mud plain except in the extreme west corner, where the forest is almost continuous to the Malele River and so connects with the heavy bush of the main river-bank. On its southern face a swamp, dry for eight months of the year and about half a mile in width, separates it from the river-bank. Photographs of the pool taken at the beginning and end of the dry season are shown on Plate xxxvii and illustrate the extremes of the shade conditions.

The area enclosed is skirted on the eastern side by the busy main road and on the south-west side by an important subsidiary path. There is a good deal of donkey transport along these routes. Horses often pass, and a considerable number of goats and sheep in small flocks are brought along to markets. Caravans of camels and pack-oxen pass but rarely, two or three times in the season, and there is no ordinary cattle movement here. The pond was frequented by roan antelope, gazelle, duiker and wart-hog, while lion, hyaenas, buffalo, Senegal hartebeeste and bushbuck, visited it. There were numerous small animals in the area, including two species of trooping monkeys, porcupine, serval, civet and smaller cats. The following birds were often

there in numbers: spur-winged, knob-billed and Egyptian geese, the pigmy or painted goose, pelicans, the marabou and other storks, several species of heron, occasionally small flocks of ducks and teal, four species of eagles, very numerous guineafowls and francolins; and the large ground hornbill was generally in the neighbourhood. So abundant is the bird life of these forest pools that at certain times most of these were seen in a single walk along the bank, while the bushes on a sunny morning in the dry season give the impression of a well-stocked aviary, so abundant are the smaller birds. Among reptiles we have no evidence of the presence of crocodiles, but think it probable that small ones are there in the floods, and both the water and land monitor lizards are numerous; the tracks of pythons were often seen, and several were caught there; and though at this pool we have not recorded the puff adder, also an easy prey to *tachinoides*, we consider that it is likely to be numerous, since in clearing similar places we have encountered a surprising number of these sluggish snakes. The antelope and other large animals being removed, there was thus an abundant fauna of the smaller creatures which fencing should not disturb, and, so far as we know, it did not do so. Apart from the traffic on the roads the flies had access to a gang of ten men who were kept in and about the fence for about five hours daily to attend to the constant repair it needed. The flies had therefore an ample opportunity of obtaining an alternative diet to the blood of the ungulates when these were removed.

The wire selected for the fence was ordinary netting, 5 ft. 6 inches high, of 4 in. mesh and 14 gauge, provided with three three-ply selvages. It was attached to posts sunk two feet into the ground at five-foot intervals, and the bottom of the wire was buried to a depth of three inches. Only two of the common straight timbers of the country are sufficiently resistant to termites to be of use, these being the giyeya (*Mitragyne africana*) and the marike (*Anogneissus leiocarpus*), the latter being the better, and the provision of the large number required (about 3,500) necessitated carrying many of them from a distance of two or three miles. Even with these timbers the resistance is not great, and during the course of eighteen months the number of supporting posts has been almost doubled. Tar or other wood preservative that would have afforded complete protection was not available.

As soon as the fence was sufficiently long to incommode the animals, it became evident that it was not strong enough, wart-hog and even duiker breaking through it, and a herd of roan stampeding one morning did damage that took the whole gang of labourers a day to repair. It was therefore strengthened by a second run of the wire to half its height all round, and this made it strong enough to resist the smaller ungulates for the most part. It was also made more conspicuous by twining pieces of paper every two or three feet at half its height and at the top. Throughout the experiment grass has been kept down inside and outside to a width of fifteen feet. Without this precaution the wire would be subject to frequent mishap. It stood the rains well, a quarter of a mile length being inundated to half its height for several weeks, and owing to the constant attention it has received no part of it has collapsed since it was closed. A photograph of the fence appears on Plate xxxvi.

In view of the vagueness as to what the original scheme would have cost, the following may be of interest. The cost of the wire, rail transport 700 miles, road transport 120 miles, and labour of construction (an average of 80 labourers for ten weeks), totalled a little over £700, so that forty miles of fencing done in the same way would have cost between £9,000 and £10,000, and the construction would have taken about ten months, employing 250 labourers, which is about as many as two Europeans can control when all details of the work have to be supervised. It is possible that a fence could be constructed more cheaply of timber, but the labour involved would be much greater and upkeep more difficult in a country where termites abound, and it is doubtful whether the timber fence would deter animals so effectively as one of wire.

The building of the fence was commenced in December 1924 and completed in the following February. At this time we had studied *tachinoides* at the pool for two years and *morsitans* for one year here but for two years at a closely similar spot. There is no spot in the neighbourhood available which would afford a good parallel for *tachinoides*, as the fenced pool was almost, though not quite, a primary focus, whereas the other small pools from which we had studied the fly were distinctly secondary foci. It was therefore necessary in estimating the effect on *tachinoides* to rely more on previous experience than on contrast with another spot after the fence was closed. For *morsitans* the area including the Village and Round Ponds promised to be a satisfactory control, for experience had taught us that through the year the abundance of *morsitans* was much the same about these as about the Road Pond. The drawback to it proved to be its proximity to the fenced area, and the flies in it were to some extent affected by the fence, which had a deterrent influence on game over an area that included the control.

While the fence was being constructed the wild ungulates remained about the spot, and during the few months after it was closed and the area inside driven clear of game the larger ones continued to skirt the fence, the tracks of roan and wart-hog being often seen and those of lion and buffalo on several occasions. A roan broke in and out again once, and a couple of Senegal hartebeeste once leapt the wire without injuring it. A bushbuck broke its neck in trying to get through, and several duiker met with the same fate. Later the large animals learnt to keep away, and in the second dry season (1925-6) the fence had a deterrent influence over a considerable area, no tracks of roan being seen in its neighbourhood and those of wart-hog very rarely, while the buffalo had moved to the Kiyawa River some miles away and did not make their periodic visits to the pool. Gazelle were much scarcer than formerly on the plain around the fence. Duiker, however, did not seem to mind it, but continued to haunt it and try to force their way to the water. In conjunction with these, porcupines, which were not satisfied to be either in or out, proved themselves a great nuisance, as they could burrow under without much difficulty and so afford an occasional opportunity for a duiker to slip through, and for this reason the fence has hardly ever been free from one of these animals. One would think it a simple matter to destroy a duiker in so small an area when the grass is burnt, but this is not the case, as they can become extraordinarily secretive in their habits and alert at avoiding traps. On one occasion it took a hundred men and a troop of dogs a whole morning to locate and drive one of them into the wire, where it was destroyed.

The influence of the removal of game will be discussed under the different species of flies.

## ii. *Effects on Glossina morsitans.*

### (a). Female Percentage (Chart II).

A high proportion of females in a catch is generally evidence of a scarcity of normal food, the females coming to man more readily in these circumstances. From March to December 1924 there was no appreciable difference between the female percentage at the Road Pond and in the control area, now one and now the other being the higher. From the building of the fence the female percentage in it became considerably higher in the dry seasons (January to April 1925 and October 1925 to May 1926), especially in the second of these periods, averaging 24 per cent. as against 11 per cent. in the control. In the intervening months, when the fly is moving about independent of the oases of shade that the secondary foci afford, the converse was the case, but whether this has any special significance it is not possible to say without the experience of another wet season.\*

\* In the wet season of 1926 the female percentage in the fence was considerably higher than in the control area except in one month.



## (b). Rate of Catching (Chart IV).

Though the fly at the Road Pond and in the control had been equally numerous before the fencing, it became much scarcer in the fence (except April 1926), the difference being pronounced from March to May 1925 and August 1925 to March 1926, but not pronounced in those months when the density in the control was less than 10, and the areas are in any case unattractive to game. It is significant that in October 1925, when the fly should be equally distributed normally at primary and secondary foci, the density at the Eastern Pond (primary) and the Round Pond (secondary) was the same, 62, but that in the fence was only 21. The highest density over a month recorded in the fenced area was 29 in November 1925, and this figure indicates relative scarcity for *morsitans*. The total catches and densities after the closing of the fence in those months when the secondary foci are definite entities were :—

Fenced area iii.-v.1925	...	909 in 81 hours=11.2 per boy-hour.
Control area iii.-v.1925	...	1,554 in 51 hours=30.3 per boy-hour.
Fenced area xii.1925-iv.1926	...	1,381 in 60 hours=23.1 per boy-hour.
Control area xii.1925-iv.1926	...	2,349 in 57 hours=41.4 per boy-hour.

Catching the flies on successive days steadily reduced the numbers present quite markedly within the fence, the figures thus obtained for five days in March being : 21, 16, 15, 9, 9; total caught, 426 flies. The reduction in the control area in the following week under similar weather conditions was less marked and not a steady decline : 51, 41, 59, 43, 29; total caught, 833 flies. After catching of this type in a secondary focus the densities increase again so quickly that the recovery cannot be due to breeding there and must be due to the constant invasion from the primary foci.

## (c). State of Nutrition (Chart VI).

A state of starvation was soon observable in the fence. Previous to its construction there was no marked difference in this respect in primary and secondary foci, but in March 1925 starving flies became numerous in the fence (12 per cent.), and in April the proportion rose to 32 per cent. From June to August of that year there was again no marked difference, but in the second dry season (xii.1925-v.1926) the proportion of starving flies became much higher in the fence again and in May 1926 rose to 45 per cent. of the catch. The female flies, whose habits anchor them more closely to the shade, showed the more abnormal condition. Thus in the fence from December 1925 to April 1926 among 666 males dissected 33.3 per cent. were starving, 17.1 were soft, and 49.8 (332) were normal; among 198 females 35.5 per cent. were starving, 62.1 per cent. were soft and only 2.5 per cent. (5 flies) were normal. As a contrast with this, in the control area in the same period among 69 females 15.9 per cent. were starving, 57.9 per cent. were soft, and 26.1 per cent. (18 flies) were normal. It should be noted that in the second dry season the proportion of starving flies in the control area was abnormally high, and this is attributable to the general scarcity of game on the plain referred to above. Normally starving flies are scarce or absent at these points in the middle of the dry season, and the comparative state of starvation produced in the fence was greater than the contrast shows.

## (d). Recently Emerged Flies (Chart VIII).

Another effect of the fencing was to increase the proportion of young flies in the collections, and again the increase was more pronounced in the second dry season. The chart shows that a high proportion in such places is to be expected at the end of the dry season (April-May). Inside the fence this high proportion appeared early in March in the first dry season and in the second was very marked from January to May 1926, being in February no less than nine times as great as in the control area (27 per cent. against 3 per cent.). The actual numbers of soft flies is not abnormally high, but the proportion is unduly raised by the dearth of old flies. This is

experimental evidence in favour of our belief that the young *morsitans*, which in the later dry season are proportionally so much more numerous in secondary than in primary foci, are not merely the result of breeding in the former, but that their presence is largely due to the excess of young flies leaving the primary foci and lighting upon the secondary ones.

(e). Food (Chart XI).

The total number of flies that contained recognisable blood at the Road Pond before the closing of the fence (February 1924–January 1925) was 482 (17·3 per cent.) in 2,791 flies, and after the closing it was 467 (15·1 per cent.) in 3,095 flies. Among these, before the closing, the proportion of avian blood was 3·4 per cent. of the whole and after the closing this rose to 9·4 per cent. of the total blood identified. The proportion of blood of human type also rose from 12·4 to 17·1 per cent. of the blood taken. The proportion of avian blood in the diet thus became about three times as great as before, while blood of human type increased by about one-half of the previous proportion. In the control area and at the Eastern Pond the proportion of avian blood was much the same over the three years, and the proportion of blood of human type showed an actual decrease for the same periods, from 6·1 per cent. to 3·9 per cent. at the Eastern Pond and from 10·7 per cent. to 6·0 per cent. at the control.

Reference to Tables I and II (section e) and Chart XI will show that blood was scarcer in *morsitans* in all the areas examined during the dry season 1925–6, so that no significance at all can be attached to the slight fall of 2 per cent. in the fenced area; and this is of interest seeing that other facts point to a state of starvation being in existence there. If this apparently steady supply of blood was being obtained inside the fence, the fly there should have been thriving equally as in the control area, but it was obviously more distressed, and we can only conclude that much of the blood was being brought in by invading flies, which after their arrival were reduced to the condition of starvation indicated above. At the same time there is here proof of what has been surmised, that if the Ungulata were removed *morsitans* would obtain more blood from other sources, since avian blood undoubtedly increased in the flies after the fence was closed. This avian blood would certainly be derived about the pool, since there is no reason why invading flies should have a larger proportion of avian blood in them than those in the area from which they come, and it is not likely that birds would bring flies with them in the way that mammals do. It is not possible to speak with the same degree of certainty about the blood of human type. There is much movement of people on the road skirting the fence, and they bring flies from the primary focus on the main river half-a-mile away. The number of flies thus brought would not of course be greater than before, but the proportion brought by man and domestic animals would be greater as opposed to those brought by game, since the antelope and pig, except the duiker, were not approaching the fence to any extent. This vitiating factor was anticipated but could not be overcome, for though the Political Officer offered to divert the road further from the fence, it could not have been moved far on account of the swamp to the east. The flies inside the fence did show an extra avidity for the blood of man, their attacks being often so persistent that it was possible to catch them between the finger and thumb, but the numbers were so decreased that in moving about inside one was not bitten nearly so frequently as formerly. When one of us spent a few days in the early part of 1924 in surveying the area, moving about with both hands occupied with notebook and compass, the number of bites received was so great as to be distressing, but after fencing one could walk about inside with no discomfort, because most of the flies that came to bite could easily be killed, more than 60 per cent. (average over the period) being specially hungry, either because they were young and had not fed or because they were famine-stricken, whereas formerly only 28 per cent. of the much larger number present were in these conditions. Therefore we think that the attacks of *morsitans* on man are not economical from the point of view of the fly and that

the game being gone man would not help the fly to continue to exist. In this particular case the gang of ten labourers employed daily in and about the fence clearly did not help the fly sufficiently for it to maintain a thriving condition.\*

(f). Trypanosome Infection (Chart XIII).

In general the closing of the area to game had little appreciable effect on the proportional infection of the fly, the monthly percentages being sometimes above and sometimes below those in the control area. The rise at the beginning of the rains was distinctly less than usual and below that in the control: in June 1926 38 per cent. infection against 43 per cent. in control, in July 37 per cent. against 47 per cent., and in August 34 per cent. against 43 per cent.—otherwise the proportions are much the same.

The total number of mature infections found in the area is as follows: before closing, among 2,791 flies there were 537 (19.2 per cent.) infective with *T. vivax*, 84 (3.0 per cent.) infective with *T. congolense*, and one fly infective with one of the *T. brucei-gambiense* group; after closing, among 3,095 flies there were 444 (14.3 per cent.) infective with *T. vivax*, 139 (4.5 per cent.) infective with *T. congolense*, and two flies with the *T. brucei-gambiense* group.

To avoid repetition this factor will be discussed after the record for *tachinoides* has been given.

iii. Effects on *Glossina tachinoides*.

(a). Female Percentage (Chart I).

There was no appreciable effect on the proportion of females in the catches after the fencing, the figures showing the usual seasonal fluctuations and about the normal variation.

(b). Rate of Catching (Chart III).

The exclusion of game resulted in a reduction in the amount of fly and in the rate of recolonisation in the rains. As mentioned above, it was not possible to find in the neighbourhood a focus that would be a fair parallel with the Road Pond throughout the year, but parallels could be found for the rains and early dry season at the other pools, which then contained abundant water. Such is the Broad Pond, from which *tachinoides* is practically absent in April and May, recolonisation beginning normally in June equally with that which occurs at the Road Pond. In July 1925, when the rate of catching in the fence was still low (4 per boy-hour), that at the Broad Pond had risen to eleven times as much (44 per boy-hour), and in August, October, and November, respectively, it was 37, 68 and 81, as against 9, 53 and 62 inside the fence. In December the Broad Pond was cleared of thicket, so the parallel ceases. In February and March, when *tachinoides* is normally abundant at the Road Pond (70–80 per boy-hour), it became scarce in the second dry season after closing, the catching rate being 24 and 27 respectively, showing hardly any of the increase that is expected when the temperature is rising. Owing to clearing at the Eastern Pond the figures for that locality given on the Chart are abnormally low, also in March–May 1926.

The reduction in numbers inside the fence was far greater than the actual figures show, for it must be remembered that if a state of distress is produced in the flies a larger proportion of those present are taken in a catch than if they are well fed. In the early dry seasons of 1923, 1924 and 1925, it was really distressing to linger at the water's edge owing to the attacks of these insects, but in 1926 one could do so with little discomfort.

\* When the Eastern Pond was cleared in 1926 a notable state of starvation occurred in *morsitans* though 300 men were working there all day.



## (c). State of Nutrition (Chart V).

There was evidence of abnormal mal-nutrition in *tachinoides*, but to a less extent than in *morsitans*. Thus from August 1924 to August 1925 the state of nutrition was much the same as at the Eastern Pond, but in the second dry season after the fence was closed there was a marked difference, the proportion of starving flies rising in December 1925 to 28 per cent. and 19 per cent. in the following month, when normally all the flies caught are either well nourished or young.

## (d). Recently Emerged Flies (Chart VII).

The proportion of recently emerged flies in the catches showed nothing abnormal, except in March 1926, to which curious month references will be made in Section (f) below. The numbers found agreed closely with those in the primary focus during the dry season and were smaller in the rains, as they normally are in the secondary foci.

## (e). Food (Charts IX and X).

The proportion of flies containing recognisable blood has always been equal to or in excess of that found at the Eastern Pond, and though there was a sensible decline in this proportion after the closing of the fence (June 1923 to January 1925, 1,052 bloods, 26.6 per cent. in 3,941 flies, falling in February 1925 to April 1926 to 420 bloods, 17.2 per cent. in 2,438 flies), the proportion still remained higher than in the primary focus in which it also fell. As with *morsitans*, there is thus the anomaly that though the starvation rate in the fence was higher than in other foci, yet the proportion of recognisable blood was also higher, and the only possible conclusion seems to be that a considerable proportion of the flies containing blood were invaders. The proportion of non-mammalian blood (mainly reptilian) inside the fence remained as before, 53 per cent. (556 in a total of 1,025 recognisable bloods before closing and 225 in 420 after closing), but the proportion containing blood of human type showed increase, rising from 24 per cent. (39 in 165) to 34 per cent. (72 in 211) after closing. Here again there is that unfortunate uncertainty as to whether the increase was due to blood obtained by resident flies or to the fact that passers by would bring a larger proportion of the invading flies than they did when game was moving freely about the pool. Since *tachinoides* is always eager for the blood of man, it was not possible to recognise any unusual avidity and the reduction in numbers of the attacking flies was such that the unusual avidity which was probably present was masked.

## (f). Trypanosome Infection (Chart XII).

On the whole there was a reduction in the rate of infection after the fence was closed, but the figures showed month by month much the same fluctuations that we have learnt to expect at the secondary foci. Attention must be drawn to March 1926, when, though a low rate of infection is expected, the proportion rose suddenly to the high rate of 16 per cent. (31 infections in 190 flies). This high rate was accompanied by an abnormally high female percentage (60 per cent.) and a sudden fall in the proportions of starving and of recently emerged flies. It was in this month that the Eastern Pond was cleared of thicket, and it seems certain that some of the *tachinoides* disturbed by the clearing found their way to the secondary focus and produced these results.\*

No infection of the *T. brucei-gambiense* group was found after the fence was closed, in fact only one has been detected at the pool in 6,621 flies examined. The actual numbers of flies found carrying mature infections were as follows: before closing, among 4,183 flies 211 (5 per cent.) were infective with *T. vivax* and 55 (1.3 per cent.)

\* The high rate of infection, the preponderance of females, and the relative scarcity of young flies are all phenomena associated with the recolonisation of the secondary foci from the primary in the rains.



were infective with *T. congolense*; after closing, among 2,438 flies 89 (3.6 per cent.) were infective with *T. vivax* and 15 (0.6 per cent.) were infective with *T. congolense*. There appears to be a definite reduction in the figures, 25 per cent. in one species and 50 per cent. in the other among an adequate number of flies, but the infections remained numerous considering that the source of infection was removed.

#### iv. Summary of Results of Fencing.

It must be admitted that the experiment has not been satisfactory, though it has yielded a considerable amount of information. In order to carry it out in a convincing manner it would be necessary to enclose a primary focus and surround the enclosed area with a very extensive clearing, but the difficulties of surrounding a primary focus appear to us to be very great, since the structure would necessarily have to cross a watercourse and withstand the annual flooding of an African river. The big flaw in the experiment has been that in any case the flies in the part enclosed become scarce at one season of the year and that it has been subject to so much invasion from outside. This invasion will be in future reduced, as the ford on the Katagum River and its banks near the fence will be clear of bush in the next dry season, during which it is intended to continue observations in the fence.

A state of starvation was produced in both species of fly, especially in *morsitans*. A larger proportion than usual of the blood obtained by *morsitans* was got from birds, and in both species an abnormally high proportion of blood of human type was found. The fact that the game soon learnt to keep away from the fence, and so the proportion of fly that reached the place from passing men increased, makes it difficult to say how much of the increase was due to accommodation of the fly inside the fence. *G. morsitans* certainly showed an increased avidity for the blood of man, but the reduction in numbers was such that the actual number of bites received was far less than formerly and their very avidity led to a heavy mortality in the attacking flies. *G. tachinoides* always shows such eagerness for the blood of man that no increase could be noted, reduction in numbers masking any that there was. We are certain that the actual reduction in numbers was far greater than the figures indicate, and this view is held on account of the comparative comfort with which we could move about near the pool after the fence was closed.\*

There is the apparent anomaly that the rate of infection by trypanosomes still kept high, though the game, the normal source of infection, was removed; and this needs careful consideration, because it was suggested to the Colonial Office Committee in 1913 that if the game were removed *morsitans* would subsist on the smaller mammals and infect them with the trypanosomes, and that these smaller animals would play the part which the game at present plays as reservoirs of the disease. There are several assumptions in this argument. First, it is suggested that the flies could make sufficient successful attacks on the smaller mammals to keep in a thriving condition; secondly, that the trypanosomes would infect the animals; thirdly, that being infected, they could act as reservoirs of the trypanosomes. As regards the first assumption, experience of the habits of the fly and those of the small mammals are against it, as well as the experimental evidence afforded by the fence. The small mammals are mostly agile and mainly nocturnal, and though the flies' willingness to feed on them and its occasional successful attacks thereon are not doubted, its ability to subsist on them is denied. As regards the second assumption, it must be remembered that most trypanosomes are very specialised organisms and do not necessarily live in any animal into which they may be introduced. They may be compared to the larvae of Lepidoptera, for whereas one caterpillar may be able to thrive on only one species of plant, another can subsist on several allied species, and

\* Also, when there is a scarcity of other food and flies are coming more to man a larger proportion of those present are caught than under normal conditions.

a third lives well on a variety of plants which are not at all allied. Of the tsetse-borne trypanosomes *T. vivax* is the most specialised, as it has been recorded as occurring naturally only in the Bovidae and Equidae with a single exception.\* There appears to be no record of its occurrence in pigs, and all attempts in the laboratory to infect rodents and dogs with it have failed. Its sudden adaptation to a life in small mammals is outside the range of probability. *T. congolense* is less specialised, as it has been recorded from the carnivores as well as from the ungulates, including pigs, and in the laboratory it is possible to infect small mammals with it, though with difficulty, and a long ultimately fatal disease is set up. *T. gambiense* has been recorded from man and antelopes, and in the laboratory may with difficulty be made to infect rodents and dogs, in which the course of the disease is long and ultimately fatal. *T. brucei* (and the same applies to *T. rhodesiense* if this is considered a distinct species) is the most catholic of all, having been recorded from the ungulates and carnivores and infecting readily the smaller laboratory animals, in which it sets up a disease that is rapidly fatal. It is therefore probable that three out of the four trypanosomes concerned would infect the small mammals if the fly began to feed upon them regularly, but the fact that fatal disease would thereby be set up would bring them into the same relation to the fly as that of cattle when they come into close contact with *morsitans*. The fly gets temporary benefit from the supply, but exhausts it by indirectly destroying its hosts.† The accommodation which it was said would occur in the absence of game therefore presupposes not only a change in the habits of the fly, but also modifications in the physiology of the trypanosomes and the small mammals, which would have to undergo mutual adjustment for any benefit to accrue to the fly.

If *T. congolense* had kept up its rate of infection in the fly within the fence and *T. vivax* had become relatively scarce, it would have been evidence that the fly was attempting the accommodation to small mammals; but the fact that the *T. vivax* infections, which form the large majority of the total infection, remained numerous shows that it was invasion of the fence by outside flies that kept the rate of infection about normal.

#### v. Recommendations on Game Preservation.

This experiment does not make it any easier to come to a decision to recommend a policy of game destruction. We know that *morsitans* is dependent on the game and that the game is the only reservoir of the trypanosomes which inhibit domestic animals that need be considered. It seems evident that if the game could be made suddenly scarce in *morsitans* areas the fly would rapidly disappear, nor should we fear the transition period when its attacks on man might be increased, because this period would be a very brief one, and epidemics of sleeping sickness take long to develop. Sudden extermination of game, however, is impracticable, unless a vast number of hunters were employed. What makes this subject much more complex in Nigeria is that *morsitans* is never found except where one or other of the riverine species of tsetse is present, which is much more successful in its attacks on man and is dangerous at any time, but especially so if its normal food is interfered with, and this food is largely derived from game where this abounds. The disappearance of the riverine species following on game destruction is not to be hoped for; its reduction in numbers is all that would occur. At the same time matters cannot remain as they are pending the necessarily slow clearing and settlement of the country which is infested, because the game laws are framed to increase larger fauna, and if the antelope increase they

\* Macfie recorded *T. vivax* from a dog in Southern Nigeria, identifying it by its morphology alone.

† It is of interest to note here that a wild cat (*Felis ocreata*) was found in the fence infected with *T. brucei*. It was in an emaciated condition and blind owing to interstitial keratitis, one of the well-known symptoms of trypanosome disease.

will spread and carry *morsitans* in their wake, as well as increase the numbers of those other tsetse more directly harmful to man. Whatever we may wish, a tsetse-infested country that fosters its game can only retrogress, and if the game in Northern Nigeria increases, many large tracts of country at present populous and full of cattle will be reduced to the pitiable condition of some of the East African Colonies, as for example the eastern half of Northern Rhodesia. After five years study of conditions in the country we have been compelled to recommend to the Government that all laws that might tend to the increase of the wild ungulates should be abolished, except in carefully selected game reserves.

## 6. Deferred Grass Burning.

### i. General Considerations.

The postponement of grass burning over large tracts of country, except where forest reserves have been established, is a matter of great difficulty, and the opinion of the Residents at the Kaduna Conference was that it would prove almost impossible, except in those Pagan areas where the natives have been in the habit of awaiting the word of their chief before firing the grass. The Director of Forests and the Chief Veterinary Officer, while agreeing that such a course would be worth while if certain to lead to control of tsetse, said that if it were continued over a number of years it would lead to impoverishment of the soil and spoil the grazing. Mr. Vetch, Senior Conservator of Forests, pointed out to us that when grass is fired early the ash is entangled in the stalks that remain and is soaked into the ground by the following rains, but when the fires are very late all these stalks are consumed, so that the strong winds that precede the rains sweep the ash from the bare country into the water-channels, where it is speedily washed away, serious impoverishment of the land resulting.

The difficulty of postponement lies in the fact that it is so much to the immediate interests of the natives to burn early. Early burning protects them when they are travelling on the narrow paths in open forests and gives them more freedom of movement. It enables them to find firewood with greater ease. It gives them grazing for the goats and sheep that are often numerous in villages near tsetse country, and though the Filani herdsmen do not as a rule bring their cattle into *morsitans* belts, they often skirt them, and they are among the earliest of grass-burners and, like most nomads, have slight regard for orders. Lastly, burning is often done as a business matter by charcoal burners, honey collectors, and particularly hunters, who are usually nomads. The destruction of a bees' nest, generally done at night, is always accompanied by fire, which can with difficulty be kept local when the grass is tinder-dry. We also came across a case where a couple of youths located a nest of bees in the day-time, but going again at night to collect the honey they were unable to find it owing to the long grass, and in consequence they fired a large tract of country for the sake of one nest. According to the last census there is approximately one professional honey collector to every eighty square miles of country. Restrictions as to grass-burning generally would so affect the economic life of the people that it is necessary to have a very clear case proving the benefit of late burning before imposing restrictions on a large scale. It is true that such benefit seems to be proved by Swynnerton's work in Tanganyika Territory (5), but in Nigeria we have to deal with thicket on a far grander scale and with great stretches of primary forest such as he would appear not to have encountered in his experiments. Above all, in the Sherifuri country and the drier north generally there are large stretches of short-grassed land interdigitating with the heavy forest, and on this are patches of umbrella-like shade afforded by the evergreen tamarind tree (*Tamarindus indica*) and the noxious thicket which creeps over it. The short grass burns like fluff and only scorches the outer foliage of the tamarinds.

Three experiments have so far been attempted.



## ii. Details of Experiments.

(1) In the dry season of 1924-5 it was proposed to conserve the area bounded by the main roads running from Gadau to Zubuki on the south, Gadau to Sokwa on the east, and the Katagum River on the west and north (see sketch-map, p. 424). A fire was started in the area in November and ruined it for experimental purposes. It was alleged that this fire was started by a child, which may or may not have been the case.

(2) In the same year it was proposed to conserve a triangular area with its apex at the camp and its base along the Katagum River, the Eastern Pool being included. On the Entomologist's return from leave in November fireguards were commenced, but before they were complete a fire, started by a traveller from Hadeija country in the North, entered and burnt the grass as far as the Malele River, reducing but not ruining the area in December. Early in February a fire was started in the centre of the area near the pool and ruined it. It was fairly certain that this fire was started by a wandering hunter, and a place was found where a porcupine had been dug out and cooked. This fire occurred nearly two months after the normal time of burning and was a severe one, but not a sweeping fire such as Swynnerton describes, as it was started in the centre and burnt mainly at night. No effect on the density of either *morsitans* or *tachinoides* could be detected, and the fire did not enter the thickets. In our routine work its effect was observable only in the amount of recognisable blood found in the flies. In this dry season *morsitans* was thriving about the pool better than at any other time in our experience, the proportion of recognisable blood being higher than in other years and the rate of infection abnormally high for the season of year. In January 35 per cent. contained recognisable blood, and in March and April the proportion was 34 per cent. and 36 per cent. respectively, but in February as a result of the fire driving the game away from the open bush for a time the proportion fell to the low figure of 13 per cent. (see Table I, section e, and Chart XI). Evidently this small enclave of unburnt grass had proved itself a sanctuary for game, and the converse of what was expected occurred, but as there are stretches of short grass in the area the unburnt condition does not serve to conceal the game from the fly in the manner in which continuous long grass may do. While *morsitans* was unusually well fed, *tachinoides* in the thickets was short of food, for in December and January only 8 per cent. and 7 per cent. respectively contained recognisable blood, and the proportion only became normal after the fire, rising to 16 per cent. and 22 per cent. in March and April respectively (Table IV, section e, and Chart X); so that evidently the smaller antelope, the chief food of *tachinoides* at this pool at this season, had been harbouring less in the thicket while the unburnt grass afforded them sufficient shelter. In neither case was the deprivation of food sufficient to be reflected in the condition of the flies, since both species remained fat. It is possible that it affected the breeding rate of *tachinoides*, since the proportion of recently emerged flies was abnormally low from December to March 1926 (Chart VII), but the proportion in *morsitans* was also low, and we are inclined to attribute both rather to the season being colder than usual.

(3) In the dry season of 1925-6 better precautions could be taken to preserve the grass, and the triangular area bordered by the Gadau-Zubuki road, the Gadau-Sherifuri road and the Katagum River, about 20 square miles was selected. It is a wild piece of country with abundant game and holds no village or important path, and there are in it only a few small patches farmed from villages outside. It could therefore be entirely closed to people with no inconvenience to any except hunters and honey collectors. The Emir of Katagum appointed four men as guards and ordered that no one else should enter the area. As the various types of grass became sufficiently dry they were burnt under control along the borders and the area remained free from fire, except that in March a fire started by the youths mentioned above came up on a strong wind and jumped the guard so that it entered the area. The



District Head at Gadau turned out the people in the night and extinguished this fire before it had travelled more than a mile on a front of a mile into the protected area, and no harm was done. In January about half a mile of the heavy thicket at the ford was cut down as we were attempting to protect the crossing from fly. The cut material was partially dry in April when the area was fired, the burning being done some six to three months after the normal time, according to the various types of grass. The fire was started in the cut bush and along the Sherifuri-Gadau road on a day when a strong wind was blowing from the east. A fire of unusual severity resulted which swept through the area at a great speed with dense volumes of smoke from the cut bush. A number of natives followed it up and attended to patches where the fire lingered, so that the whole of the patch was burnt under ideal conditions. The grass was completely consumed; the tamarinds, which are very numerous here in the shorter grass, were hardly affected; the fire entered the thickets and burnt up the carpet of dead leaves and twigs that floor them and the groves of mahogany, but it did not affect established thicket except where dry dead trees lay, and these being completely consumed any thicket within range of their flames was burnt out; away from the established thicket focussed round forest trees, those thicket elements that grew as isolated bushes were killed to the ground but were sprouting again a month later. Studying the ground a month after the fire we gained the impression that these late fires would have a great effect in curtailing the spread of thicket, or in preventing its formation on recently farmed land that was beginning to revert, but their effect on established thicket would be negligible. It is true, as Swynnerton says, that proper thicket may be burnt out, but this is rare in Nigeria, and we have only observed it once, the instance being on the banks of the Benue, where a large patch of lianas had been completely burnt out. Bushbuck did not leave as a result of the fire, but were seen in numbers a day or two after, haunting the thickets in which they were now conspicuous, while sounders of wart-hog were occupied in rooting about on the charred ground. The larger antelope, roan and waterbuck continued to move about it as though reluctant to leave what had been such an excellent sanctuary. One curious incident is worth record. Dr. King found the remains of a waterbuck which a lion had been eating. The horns of the buck were charred by fire, but there was a trail over the ashes where the lion had dragged the carcase. The horns must therefore have been burnt before the lion obtained the beast, and it would seem that the buck was a victim of the fire.

The effect of the fire on both species of fly was very interesting.

(a). *Effect on G. morsitans.*

Before the fire the density was 49, a very low figure, which was artificially produced by the difficulty the fly-boys found in collecting in the tangled grass (a true figure would have been in the neighbourhood of 100); female percentage was 4 per cent. (normal); young flies were 11.6 per cent. (a rather high figure for a primary focus); starving flies were 5 per cent. (also rather high); recognisable blood, all mammal, was 22.5 per cent. (normal); rate of infection was 21.7 per cent. (normal). The day after the fire the density was 34, though there was now no difficulty in catching; female percentage was 6 per cent., no change; young flies were 6.0 per cent., a definite reduction probably owing to destruction of pupae; starving flies 6.0 per cent., no change; recognisable blood was 32 per cent., all mammal; rate of infection was 32 per cent., an increase, probably erratic. A month after the fire the density had increased to 79, a figure still below normal, which on the river bank in the previous year at this time was 130; the female percentage had decreased to 0.8 per cent., indicating that the flies were thriving well; young flies were 1.2 per cent., a continued fall; starving flies were 2.5 per cent., a reduction; recognisable blood (all mammal) was 26.3 per cent.; rate of infection was 37.5 per cent. The fire thus resulted in a considerable reduction in the numbers of *morsitans* and probably a large destruction of their

pupae, but the reduction was soon being masked by invasion from outside the area, and the invading flies were thriving.\*

(b). *Effect on G. tachinoides.*

Before the fire the density was 115, a normal figure, there being no difficulty in catching in the open parts of the thickets; female percentage was 26 per cent., normal; young flies were 37 per cent., more than would be expected in a primary focus at this time; starving flies were 0, normal; recognisable blood was 12 per cent. (all mammal), a low proportion, like that recorded at the Eastern Pond under similar conditions; rate of infection was 5 per cent., normal. The second day after the fire the density had decreased to 31; female percentage was 50 per cent., significance of rise doubtful; young flies were 60 per cent., an increase not in fact but in proportion; starving flies were 2.2 per cent.; recognisable blood (all mammal) was 11.1 per cent.; rate of infection was 6.5 per cent.; the last three factors showing no appreciable change.

A month after the fire the density had increased to 74, still below normal; female percentage was 26 per cent., normal again; young flies were 14.0 per cent., a remarkable reduction; starving flies were 0; recognisable blood (all mammal) was 34 per cent., increase as at Eastern Pond under similar conditions; rate of infection was 9.0 per cent. The fire thus resulted in a considerable reduction in the numbers of *tachinoides* present, and this is more evident if the young flies are excluded from the figures, for the immediate reduction in density of old flies was as 72.12, and the reduction in recently emerged flies was as 42.19. There was therefore a considerable mortality of both flies and pupae. The density increased rapidly after the fire, and it was probably due to invasion, as had it been due entirely to breeding a lower rate of infection would have been expected.

These results are less striking than those recorded by Swynnerton, but while he was able to deal with a wide tract of country we have so far dealt only with a small portion of an area of very dense fly, and our area for this reason was more liable to invasion than his. The results are full of promise, and experiment will be continued along these lines. It is hoped to deal with one of the large forest reserves in which natives reside only on sufferance and so are more amenable to restrictions about grass-burning. The experiment in the Gadau area will be repeated, as the information we have collected about the local fly, and the fact that it is so close to our base camp, put us in a better position for estimation of the effects.

## 7. Clearing.

A considerable amount of clearing work has been done in the neighbourhood of the Sherifuri Camp, and a brief account of this will be given here, a fuller account being reserved for a future report when the results can be better estimated. Clearing against tsetse consists of three stages; first, the cutting of the bush and stacking it for burning; secondly, making the most economical use of fire; thirdly, the settlement of the cleared parts so that they will not revert. In the latter part of the dry season *tachinoides* is confined to the thicket bordering the pools and *morsitans* is almost confined to the edges of the thicket, and it would appear that if these can be destroyed the general forest with its outlying patches of thicket may be left alone. It is on this theory that we have been working, and we have not cut into any general forest,

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\* It is interesting to notice the difference in the February burning at the Eastern Pond described above. In that case the thicket was not entered by fire and remained obscure, so that antelope moving in it would not be conspicuous to skirting *morsitans*, which was therefore short of food for a month. In this case the bushbuck moving in the thicket opened by the fire were nearly as conspicuous as in the open bush and could be detected by skirting *morsitans*, and no shortage of food was noted.

except where this skirts the trade route, but have confined our attention mainly to within 100–200 yards of the banks of the pools and streams. This amount of clearing really only involves the destruction of the primary and more important secondary foci of the tsetse, and reference to the map will show that it forms a relatively small proportion of the whole. At the same time it involves the destruction of the most massive of the thorn thicket and the largest of the thicket-supporting trees, and the amount of labour it absorbs is great. For such work the natives can only turn out when the harvest is over and until the clearing up of their farm land begins towards the end of the dry season. At present the Mahomedan Fast, Ramadan, occurs during the dry season and interferes to some extent with the supply of labour. In this neighbourhood each adult male of the labouring class owes the Emir fifteen days work in the year, payment at local rate being made. The Emirs of Katagum and Hadeija diverted a proportion of this labour supply for clearing work in gangs of 200 men, and a fairly steady supply was kept up from December to March. Besides this, a varying number of natives would come and volunteer for the work and remain for periods of a week to a month or so. The volunteers would average about 80 men, and it is believed that this supply of labour will increase in the future as the ease with which a few shillings can be earned becomes better known.

We have found it better to supply tools rather than to allow them to use their own primitive axes, so woodman's axes and short matchets have been employed. A most useful tool in clearing thorn thicket proved to be a secateur with a handle about eight feet long. This easily severs a branch an inch in thickness and is a great aid in pulling out the masses of the trailing creeper, *Dichrostachys platycarpa* (sarkakiya), which so often envelops the large trees that their trunks cannot be approached till it is removed. A great difficulty which has been experienced with tools is that the dry climate takes the nature out of the wood, so that axe-heads frequently come loose and the handles break. This has been remedied to some extent by refitting each axe when it is issued and shortening the handle to the length to which the natives are accustomed, so that the inexperienced are less likely to overreach their strokes. The ordinary type of axe is not satisfactory, and we are testing axes with an eye like a pick, so that they can be refitted with local wood. A powerful monkey-winch, which was tested for pulling out masses of thicket, was so slow in action that its use has been abandoned.

In order to get effective burning and to destroy the stumps of trees it is necessary to stack the cut material, and in many cases this has been piled around the trunks of the larger trees in order to kill them with fire as they stand, since a dead tree if isolated cannot support thicket. This procedure of stacking at the cutting is a good one if the material has a sufficient time to dry before the onset of the rains, but if the cutting is done in the latter half of the dry season it would appear better to leave it till the following dry season, when the added fuel of long grass growing amongst the cut tangle makes a very fierce fire possible. Such points will be the subject of experiment. It certainly seems to be economical to postpone burning till the material is thoroughly dry, as partial burning only wastes the fuel.

While it was expected that one of the chief difficulties in the clearing would be the discomfort caused by the tsetse, it proved in the event to be no inconvenience whatever. In some of the places dealt with, such as the banks of the main river, *morsitans* was so numerous as often to gather round in a swarm, biting so freely that it was impossible to linger there during the warm hours, but at the same places while the work was in progress there was hardly a fly to be seen, so that a day often passed without a bite being received, and a fly could rarely be seen on a labourer. There was no doubt but that the activities of the large body of men in some way disturbed the fly and prevented it from making its usual attacks. This effect was even seen in the catches recorded by the fly-boys, when they were catching flies in the neighbourhood of the work at the Eastern Pond in March, though plenty of shade still remained.



The densities then recorded for both species were less than 50 flies per boy-hour instead of 100, which would have been about the normal number. No abnormally high proportion of blood of human type was recorded in flies caught near the work, though their opportunities for obtaining it were greater than ever before.

The following notes are relative to the clearing in so far as it affected the figures recorded for March–May 1926 in Tables I and IV for the Eastern Pond, which was cleared in March–April 1926 and partly burnt the following month. It was not ready for complete burning and a few shade trees remained, while the more open forest backing the thicket was hardly cut into at all. It should be noted that though we refer throughout to this pool as a primary focus, it is not a definite entity, because its bank with continuous thicket runs into that of the main river at both ends. It still remained open to invading flies from the parts that have yet to be dealt with. It is therefore of interest to note how closely similar the following figures are to those obtained inside the fence, from which game was excluded. The immediate effect of the clearing was in fact to turn what we had regarded as a typical primary focus into a poor secondary one. The subsequent history of the focus will be reserved for a future report.

(a). *G. tachinoides*.

The density at once became reduced, being 48, 37, 17 in the three months (iii.–v. 1926) respectively instead of about 100. The female percentage was not visibly affected. The game of course largely left owing to the disturbance, and the proportion of flies containing recognisable blood was low in March and April, but became normal in May, when, owing to the rains having started, the fly was obtaining quite an unusual amount of reptile blood for this time of year at the pool. The proportion of starving flies became high in April but fell again in May in correlation with the blood supply. The proportion of recently emerged flies became unusually high owing to the dearth of old flies. The rate of infection fell to a low figure (7 per cent., 4 per cent. and 3 per cent. in the successive months, as against a normal 9–17 per cent. in the previous years), in accordance with the last mentioned fact and the changing diet.

(b). *G. morsitans*.

The density at once became reduced, being 48, 37, and 17 in three successive months (iii.–v. 1926) instead of about 100 (100, 101, and 119 in the previous year at the same time). The proportion of recognisable blood was low. The female percentage rose only in one month, April. The proportion of starving flies rose very high, 20 per cent., 31 per cent. and 32 per cent., as against 0, 1 and 5 per cent. in the previous year. The proportion of recently emerged flies also rose abnormally for the time of year, being 13 per cent., 27 per cent. and 16 per cent., as against 1 per cent., 1 per cent. and 2 per cent. in the previous year and 4 per cent., 2 per cent. and 4 per cent. in 1924. The rate of infection suddenly dropped from 41 per cent. in February to 18 per cent., 10 per cent. and 23 per cent. in the three months, as against 45 per cent., 38 per cent. and 25 per cent. in 1925; 37 per cent., 31 per cent. and 33 per cent. in 1924; and 32 per cent., 25 per cent. and 27 per cent. in 1923, for the same successive months in each case.

### 8. Attempted Introduction of a Chalcid Parasite.

*Syntomosphyrum glossinae*, a small Chalcid, is one of the more successful parasites of *G. morsitans* in Nyasaland, and as it readily multiplies on blow-fly pupae in captivity Lamborn has been attempting to use it as a controlling factor for this fly in Nyasaland, and in one area his work resulted in a considerably increased rate of parasitisation (6). Through the agency of the Imperial Bureau of Entomology an attempt has been made to introduce this parasite into Nigeria, where it is not known



to exist. Dr. Lamborn sent a supply of the insects to England, where they were multiplied by Mr. Altson, of the Imperial Bureau, at the Rothamsted Experimental Station. In 1924 a series of large consignments was despatched to the Tsetse Investigation at Sherifuri in Nigeria, part of them through the ordinary post and part travelling on the boats in cold store. None that travelled by cold store reached Sherifuri in a living condition. Those that came by ordinary post emerged from the parasitised blow-fly pupae for the most part *en route*, and were dead when they reached their destination, the journey of about a month being a little too long for their encased stages during the hotter months in West Africa, when most of the consignments arrived. A few were obtained from one lot which reached Sherifuri in cooler weather after the onset of the rains, and from these a large stock was reared through the rainy season, Dr. Hanington keeping them supplied with fresh blow-fly pupae during the months he was alone at the camp. On the return from leave of the Entomologist in December a large number was released on three occasions at a spot where *morsitans* and *tachinoides* were known to be breeding actively. The cages were taken to the spot and the Chalcids shaken loose in the breeding-ground, while many pupae from which they were on the point of emergence were buried in the sand and humus where the flies breed. Tsetse pupae were subsequently collected from the place on several occasions, but no sign of parasitisation was found, so that the attempted introduction seems to have failed.

The stock at Sherifuri died out in the following hot weather and Lamborn also records that he could not keep his stocks going during the hot part of the year.

## 9. Summary and Conclusions.

(1) This report is an account of the experimental work carried out by the Tsetse Investigators in Northern Nigeria during the period from January 1924 to May 1926. *G. morsitans* and *G. tachinoides* are dealt with. In the Introduction the district around Sherifuri, where the camp is situated, is described, the differences between primary and secondary tsetse foci are defined, and an account is given of the method of collecting data as a basis on which to estimate the effects of experiment. Before and during experiment flies were collected week by week from foci subject to experimental change and from others employed as controls, the following factors being noted: the sex proportion in the catch, the rate of catching, the state of nutrition, the proportion of very young flies, the blood content of the guts with classification of the kinds of blood taken, and the trypanosome infection.

(2) An experiment was carried out in which game was excluded from a good secondary focus of tsetse by means of a fence. This set up a state of starvation in *morsitans* and to some extent in *tachinoides*. There was a marked reduction in the abundance of both species, especially in *morsitans*. More blood than usual was taken by *morsitans* from birds, and both species contained a larger proportion of blood of human type than is usual. Invasion of the enclosed area by tsetse from outside vitiated the experiment and resulted in certain anomalies, *viz.*, that the rate of trypanosome infection remained high; the blood content was not appreciably decreased; the proportion of very young flies increased abnormally in *morsitans*. It is considered that game destruction, if it could be accomplished, would lead to a disappearance of *morsitans*, but not of *tachinoides*, and for this reason no policy of game destruction is recommended, but a policy of *laissez faire* towards the game in Northern Nigeria, so that there may be no increase in the wild Ungulata, which results in increase and spread of fly.

(3) A successful experiment in deferred grass burning is recounted. The late sweeping fire resulted in a great mortality of *morsitans* and *tachinoides*, both flies and pupae. It hardly affected the growth of established thickets, but probably checked

expansion of such and the formation of new thicket. It is considered that late grass fires, well organised, might have a good effect in Northern Nigeria, but the difficulties in the way of postponement of burning are exceedingly great in this country.

(4) The commencement of an experiment in clearing with subsequent settlement is briefly described. Except on the main road through the experimental area only fringing forest is being cut down, the general woodland being left untouched. If this policy is successful only a relatively small proportion of a fly area will need to be cleared, attention being confined to the main foci.

(5) An account is given of an unsuccessful attempt to introduce into Nigeria *Syntomosphyrum glossinae*, a Chalcid parasite of *G. morsitans* in East Africa.

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## APPENDIX.

## Notes to Tables.

The percentages are based on an average number of 188 flies.

Percentages based on 50-100 flies are marked by one asterisk ; those based on less than 50 by two asterisks.

Figures which mark the culminating point of a rise are in heavy type.

Figures which are believed to be affected by experiment are placed in brackets.

TABLE I.

The Results of the Examination of *G. morsitans* at the Eastern Pond (a Primary Focus).  
The thicket on its bank was cut in March-April 1926.

	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
(a) Female percentage	1923	7	13	7	6	4	9	5	11	16	23	16	9
	4	11	11	7	9	7	5	7	11	24	22	14	13
	5	10	7	2	7	5	4	5	6	—	13	10	4
	6	5	3	5	(15)	5	—	—	—	—	—	—	—
(b) Rate of catching ; flies per boy-hour	1925	—	—	100	101	119	100	100	49	—	62	97	71
	6	72	106	(47)	(35)	(15)	—	—	—	—	—	—	—
(c) State of nutrition ; per- centage of starving flies	1924	—	—	—	—	—	—	—	8	9	6	1	2
	5	0	0	0	1	5	8	15	16	—	5	4	7
	6	1	4	(20)	(31)	(32)	—	—	—	—	—	—	—
(d) Young flies ; percentage of soft flies	1923	—	—	—	—	—	—	—	—	—	—	0	1
	4	8	8	4	2	4	2	2	2	2	1	3	2
	5	2	3	1	1	2	1	2	3	—	7	10	9
	6	3	1	(13)	(27)	(16)	—	—	—	—	—	—	—
(e) Recognisable blood in flies ; percentage	1923	—	—	—	—	19	26	17	14	14	19	29	25
	4	26	20	22	16	22	17	24	21	15	17	26	28
	5	35	(13)	34	36	15	10	17	17	—	22	22	22
	6	19	13	(9)	(10)	(13)	—	—	—	—	—	—	—
(f) Non-mammalian blood (avian) ; percentage of total blood	1923	—	—	—	—	0	0	0	2	0	3	8	0
	4	0	0	2	0	0	0	6	1	3	4	0	3
	5	0	0	0	0	0	0	7	6	—	0	1	0
	6	0	0	0	0	7	—	—	—	—	—	—	—
(g) Rate of infection ; per- centage	1923	58	43	32	25	27	39	35	29	19	13	31	36
	4	35	26	37	31	33	35	46	35	26	21	13	14
	5	45	47	45	38	25	35	41	48	—	31	35	34
	6	28	41	(18)	(10)	(23)	—	—	—	—	—	—	—

TABLE II.

The Results of the Examination of *G. morsitans* at the Road Pond (a Secondary Focus).  
The pool was fenced round and the game excluded in February 1925.

	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
(a) Female percentage	1924 5 6	— (26) (23)	— (25) (25)	16 (26) (30)	16 (30) (30)	28 18 19	10 4 —	18 6 —	13 15 —	14 — —	19 (23)	12 (33)	5 (17)
(b) Rate of catching ; flies per boy-hour	1925 6	— (19)	— (24)	(15) (25)	(18) (23)	(6) 8	4 —	8 —	9 —	— —	(21)	(28)	(20)
(c) State of nutrition ; percentage of starving flies	1924 5 6	— 0 (39)	— 1 (32)	(12) (41)	(32) (25)	(18*) (46*)	12 —	16 —	22 —	7 —	1 (28)	3 13	1 (31)
(d) Young flies ; percentage of soft flies	1924 5 6	— 6 (25)	14* 13 (27)	10 (17) (25)	6 (45)	30 4* 25*	3 2 —	1 4 —	2 5 —	1 —	1 11	2 15	1 15
(e) Recognisable blood in flies ; percentage	1924 5 6	— 14 10	16* 12 14	16 24 9	13 21 9	15 25* 1*	16 15 —	16 11 —	16 15 —	14 — —	15 12 —	17 12 —	9 13 —
(f) Non-mammalian blood (avian) ; percentage of total blood	1924 5 6	— 11 13	0* 2 0	2 11 (29)	3 3 0	3 9* 0*	2 (24) —	10 (13) —	2 11 —	0 — —	0 12 —	0 0 —	4 9 —
(g) Rate of infection ; percentage	1924 5 6	— 22 19	13* 25 32	25 23 26	12 18 9	9 19* 18*	51 38 —	55 37 —	39 34 —	21 — —	31 24 —	23 32 —	29 31 —

TABLE III.

The Results of the Examination of *G. morsitans* at the Village and Round Ponds (a Secondary Focus). Control area to Table III.

	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
(a) Female percentage	1923 4 5 6	14 14 5 6	13 12 17 9	18 16 7 10	6 16 20 14	10 22 16 10	10 17 21 —	10 26 27 —	11 24 14 —	10 10 15 —	18 18 15 —	14 13 12 —	7 10 15 —
(b) Rate of catching ; flies per boy-hour	1925 6	— 39	— 44	41 56	28 12	25 8	5 —	12 —	31 —	— —	62 —	45 —	42 —
(c) State of nutrition ; percentage of starving flies	1924 5 6	— 0 7	— 0 5	— 6 4	— 9 8	— 10 14*	— 11 —	— 12 —	7 24 —	3 — —	7 14 —	5 16 —	3 22 —
(d) Young flies ; percentage of soft flies	1923 4 5 6	— 12 4 7	— 11 7 3	— 11 6 10	— 12 16 19	— 12 25 10*	— 1 3 —	— 2 3 —	— 1 5 —	— 0 — —	— 2 8 —	— 1 5 —	4 3 18 —
(e) Recognisable blood in flies ; percentage	1923 4 5 6	— 18 14 7	— 20 15 13	— 12 25 22	— 17 21 15	24 32 17 19*	16 26 11 —	15 28 20 —	16 21 20 —	19 16 — —	22 17 15 —	22 14 16 —	26 16 17 —
(f) Non-mammalian blood (avian) ; percentage of total blood	1923 4 5 6	— 0 0 11	— 5 0 0	— 5 4 0	— 5 5 5	0 2 0 0*	0 8 0 —	12 6 5 —	17 2 12 —	8 2 — —	2 2 0 —	0 0 0 —	0 0 3 —
(g) Rate of infection ; percentage	1923 4 5 6	14 24 28 34	16 19 15 20	20 14 16 11	12* 14 9 6	31 10 7 18*	58 50 43 —	43 52 47 —	36 35 43 —	23 27 43 —	15 22 19 —	16 15 31 —	22 31 35 —



TABLE IV.

The Results of the Examination of *G. tachinoides* at the Eastern Pond (a Primary Focus). The thicket on its bank was cut down in March-April 1926.

	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
(a) Female percentage	1923	46	16	30	<b>51</b>	42	39	33	35	34	40	<b>41</b>	38
	4	39	27	30	<b>49</b>	47	40	36	37	34	39	36	<b>40</b>
	5	32	33	30	27	<b>47</b>	27	18	<b>34</b>	—	<b>41</b>	38	36
	6	26	27	32	<b>42</b>	40	—	—	—	—	—	—	—
(b) Rate of catching ; flies per boy-hour	1925	—	—	—	—	—	100	100	56	—	<b>103</b>	98	50
	6	46	69	(48)	(37)	(17)	—	—	—	—	—	—	—
(c) State of nutrition ; percentage of starving flies	1924	—	—	—	—	—	—	16	<b>21</b>	8	5	2	3
	5	0	0	2	1	9	8	15	<b>16</b>	—	2	3	7
	6	0*	4	6	(15)	5	—	—	—	—	—	—	—
(d) Young flies ; percentage of soft flies	1923	—	—	—	—	—	—	—	—	—	—	22	28
	4	<b>32</b>	19	14	20	21	9	11	11	4	7	7	2
	5	8	10	12	<b>15</b>	8	15	12	19	—	17	21	20
	6	25*	34	<b>38</b>	30	25	—	—	—	—	—	—	—
(e) Recognisable blood in flies ; percentage	1923	—	—	—	29	25	23	17	17	19	26	18	17
	4	19	14	17	21	26	23	14	15	15	19	15	8
	5	7	14	16	22	17	13	14	10	—	8	12	9
	6	10*	7	9	14	23	—	—	—	—	—	—	—
(f) Non-mammalian blood ; percentage of total blood.	1923	—	—	—	10	24	24	23	21	18	48	<b>70</b>	28
	4	29	14	13	6	14	10	13	29	11	35	<b>47</b>	28
	5	23	19	17	0	7	10	27	30	—	35	<b>47</b>	14
	6	12*	0	11	(27)	(56)	—	—	—	—	—	—	—
(g) Rate of infection ; percentage	1923	10	6	9	13	13	13	10	7	5	11	7	5
	4	9	<b>19</b>	12	16	17	16	18	11	9	7	8	6
	5	4	8	<b>12</b>	11	12	12	14	11	—	7	6	<b>13</b>
	6	2*	8	(7)	(4)	(3)	—	—	—	—	—	—	—

TABLE V.

The Results of the Examination of *G. tachinoides* at the Road Pond (a Secondary Focus).  
The pool was fenced round and game animals excluded in February 1925.

	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
(a) Female percentage	1923	44	39	38	36	38	41	39	51	48	54	39	37
	4	51	52	45	26	26	—	—	52	51	49	52	41
	5	40	39	30	47	51	36	56	55	55	54	49	40
	6	42	46	60	42	—	—	—	—	—	—	—	—
(b) Rate of catching; flies per boy-hour	1925	—	—	—	19	19	4	(4)	(9)	—	(53)	(62)	(30)
	6	(14)	(25)	(27)	16	—	—	—	—	—	—	—	—
(c) State of nutrition; percentage of starving flies	1924	—	—	—	—	—	—	—	9	7	8	2	1
	5	1	0	3	7	14	11	14	17	—	(10)	(11)	(28)
	6	(19)	(14)	4	5*	—	—	—	—	—	—	—	—
(d) Young flies; percentage of soft flies	1923	—	—	—	—	—	—	—	—	—	—	7	22
	4	33	17	8	18	50**	—	—	2	3	2	5	10
	5	7	12	12	8	10	8	7	3	—	18	22	20
	6	34	30	(18)	49*	—	—	—	—	—	—	—	—
(e) Recognisable blood in flies; percentage	1923	—	—	—	—	—	20	26	16	26	35	20	25
	4	22	22	24	21	37**	—	—	17	25	32	15	9
	5	14	15	28	29	20	29	18	20	—	18	12	11
	6	13	14	18	13*	—	—	—	—	—	—	—	—
(f) Non-mammalian blood; percentage of total blood.	1923	—	—	—	—	—	23	58	68	43	80	67	64
	4	53	56	36	35	0**	—	—	49	70	66	61	57
	5	27	46	61	67	54	62	79	50	—	45	42	72
	6	33	44	28	36*	—	—	—	—	—	—	—	—
(g) Rate of Infection; percentage	1923	2*	0**	1	6*	—	9	14	21	9	15	10	4
	4	4	5	7	2	6**	—	—	25	15	10	5	3
	5	0	0	2	4	2	8	16	26	—	10	9	2
	6	1	2	(16)	3*	—	—	—	—	—	—	—	—

TABLE VI.

Temperature and Rainfall Records at Sherifuri during the Experimental Work.  
The temperatures are those of the laboratory, an airy thatched building.

	Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Mean Temperature...	1923	71.7	73.4	82.6	87.8	88.5	84.0	78.3	76.8	79.5	80.6	76.2	72.2
Absolute Maximum	...	91	93	101	104	101	96	87	87	90	93	94	90
Absolute Minimum	...	51	52	58	71	70	71	68	68	71	66	59	56
Rainfall ...	...	0	0	0	0.13	1.65	5.35	6.75	18.6	3.91	0.18	0	0
Mean Temperature	1924	71.0	80.2	85.0	89.1	86.9	82.0	79.6	78.2	77.5	79.9	74.1	70.8
Absolute Maximum	...	89	97	102	103	101	97	88	88	87	92	92	87
Absolute Minimum	...	49	65	68	74	73	72	70	69	69	61	59	52
Rainfall ...	...	0	0	0	0.19	0.03	4.08	4.86	9.04	5.09	0	0	0
Mean Temperature	1925	65.2	72.7	85.3	88.1	87.3	83.8	80.7	77.8	80.4	81.1	79.1	71.2
Absolute Maximum	...	80	92	102	101	99	95	91	87	88	93	93	89
Absolute Minimum	...	50	58	68	72	75	72	70	71	74	69	58	53
Rainfall ...	...	0	0	0.30	0.13	2.68	2.64	6.05	10.8	3.86	1.02	0	0
Mean Temperature	1926	68.0	76.4	82.0	87.8	87.6	—	—	—	—	—	—	—
Absolute Maximum	...	89	93	102	102	98	—	—	—	—	—	—	—
Absolute Minimum	...	54	59	63	70	75	—	—	—	—	—	—	—
Rainfall ...	...	0	0	0	0.72	4.39	—	—	—	—	—	—	—

Temperatures are in degrees Fahrenheit.

Rainfall is in inches.





Fig. 1. The Eastern Pond, Sherifuri, N. Nigeria, a primary focus of *Glossina morsitans* and *G. tachinoides*. The fringing bush in the background has been cut and stacked for burning. The natives are engaged in the annual fish drive at the pool.



Fig. 2. The fence constructed round the Road Pond, Sherifuri, to exclude game animals; the enclosed area is to the right.







Fig. 1. The Road Pond, Sherifuri, N. Nigeria, a good secondary focus of *Glossina morsitans* and *G. tachinoides*; early dry season condition, when both species of tsetse fly abound there.



Fig. 2. The same pool in late dry season condition, when both species are very scarce. The photographs were taken from approximately the same spot. The difference in shade conditions will be noted.



## COLLECTIONS RECEIVED

The following collections were received by the Imperial Bureau of Entomology between 1st September and 31st December, 1926, and the thanks of the Managing Committee are tendered to the contributors for their kind assistance :—

Mr. T. J. ANDERSON, Government Entomologist :—141 Lepidoptera ; from Kenya Colony.

Dr. G. ARNOLD, Rhodesia Museum :—9 Tabanidae, 3 Nycteribiidae, 97 other Diptera, 52 Coleoptera, 2 Hymenoptera, and 2 Rhynchota ; from Rhodesia.

Mr. E. BALLARD, Commonwealth Cotton Entomologist :—5 Parasitic Hymenoptera and 9 Lepidoptera ; from Queensland, Australia.

Prof. H. A. BALLOU :—2 Diptera, 74 Coleoptera, 101 Hymenoptera, 4 Lepidoptera, 6 Rhynchota, and 74 Orthoptera ; from Trinidad.

Mr. L. E. W. BEVAN :—22 Diptera ; from Southern Rhodesia.

Dr. A. O. BLACKHURST :—22 Parasitic Hymenoptera ; from Smyrna, Asia Minor.

Mr. E. E. BLANCHARD :—7 Coleoptera ; from the Argentine.

Mr. L. L. BUCHANAN :—2 Coleoptera ; from China and Japan.

Dr. P. A. BUXTON, London School of Hygiene and Tropical Medicine :—123 Tabanidae and 24 Coleoptera ; from various localities.

Dr. G. D. H. CARPENTER :—12 Coleoptera and 6 Rhynchota ; from S.E. Sudan.

Mr. L. D. CLEARE, Junr., Government Economic Biologist :—131 Diptera, 51 Coleoptera and 14 larvae, 100 Parasitic Hymenoptera, 13 Lepidoptera, 2 species of Aleurodidae, 1 species of Aphidae, 3 other Rhynchota, 20 Psocidae, 7 Mallophaga, 16 Ticks, and 19 Shells ; from British Guiana.

Mr. G. H. CORBETT, Government Entomologist :—25 Diptera, 177 Coleoptera, 38 Hymenoptera, 153 Lepidoptera, 115 Rhynchota, and 5 Orthoptera ; from the Malay Peninsula.

Mr. G. S. COTTERELL : 14 Parasitic Hymenoptera ; from the Gold Coast.

DIVISION OF ENTOMOLOGY, PRETORIA :—5 Diptera, 203 Coleoptera, 1,140 Parasitic Hymenoptera, 204 other Hymenoptera and 30 larvae, 34 Rhynchota, and 6 Orthoptera ; from South Africa.

DURBAN MUSEUM, NATAL :—67 Diptera, 236 Hymenoptera, and 38 Rhynchota ; from South Africa.

Dr. E. W. FERGUSON :—11 Diptera ; from New South Wales, Australia.

Mr. D. T. FULLAWAY :—32 Coleoptera ; from the North Pacific.

Lt. J. GHESQUIÈRE : 7 species of Aleurodidae ; from the Belgian Congo.

Mr. A. GIBSON, Dominion Entomologist :—1 species of Coccidae ; from Nova Scotia, Canada.

Mr. A. F. J. GEDYE :—74 Orthoptera ; from Kenya Colony.

GOVERNMENT ENTOMOLOGIST, COIMBATORE :—6 Diptera, 10 Coleoptera, and 8 Rhynchota ; from South India.

GOVERNMENT ENTOMOLOGIST, LYALLPUR :—4 Diptera, 138 Coleoptera, 43 Hymenoptera, and 22 Rhynchota ; from the Punjab, India.

Mr. C. C. GOWDEY, Government Entomologist :—3 Diptera, 27 Coleoptera, 100 Parasitic Hymenoptera, 6 other Hymenoptera, 6 Lepidoptera, 1 species of Coccidae, and 1 species of Aphidae ; from Jamaica.

Mr. W. GREENWOOD :—8 Siphonaptera, 15 Diptera, 2 Coleoptera, 11 Parasitic Hymenoptera, 23 Lepidoptera, 36 Aphidae, and 14 Aleurodidae ; from the Fiji Islands.

Mr. W. B. GURNEY, Government Entomologist :—30 Diptera ; from New South Wales, Australia.



Mr. W. J. HALL :—174 packets and 512 slides of Coccidae, 257 packets and 561 slides of Aphidae, and 23 Embiidae ; from various localities.

Mr. G. L. R. HANCOCK, Assistant Entomologist :—244 Culicidae, 5 *Culicoides*, 6 *Glossina*, 10 other Diptera, 7 Coleoptera, 9 Parasitic Hymenoptera, 31 other Hymenoptera, 45 Lepidoptera, 4 species of Coccidae, 6 species of Aphidae, 1 species of Aleurodidae, 4 species of Psyllidae, 24 other Rhynchota, 26 Orthoptera, 5 Planipennia, and 2 Trichoptera ; from Uganda.

Mr. C. B. HARDENBERG :—382 Coleoptera ; from Portuguese East Africa.

Mr. E. HARGREAVES, Government Entomologist :—3 Culicidae, 2 *Haematopota*, 20 other Diptera and 6 larvae, 227 Coleoptera, 206 Hymenoptera and 45 early stages, 34 Lepidoptera, 152 Thysanoptera, 3 species of Coccidae, 1 species of Aleurodidae, 167 other Rhynchota and 15 early stages, 83 Orthoptera, 14 Planipennia, 7 Perlidae, 5 Trichoptera, and a tube of Mites ; from Sierra Leone.

Mr. H. HARGREAVES, Government Entomologist :—3 *Glossina*, 19 other Diptera, 22 Coleoptera, 15 Parasitic Hymenoptera, 34 other Hymenoptera, 280 Lepidoptera, 14 Rhynchota, 57 Orthoptera, and 3 Planipennia ; from Uganda.

Mr. G. F. HUCKLESBY :—16 Diptera, 54 Coleoptera, 13 Hymenoptera, 20 Rhynchota, 6 Psocidae, 2 Embiidae, and 5 Odonata ; from Palestine.

Mr. G. V. HUDSON :—1 Tipulid ; from New Zealand.

Major C. M. INGOLDBY :—13 Diptera and 58 Rhynchota ; from the Gold Coast.

Mr. F. P. JEPSON :—5,950 Isoptera ; from Ceylon.

Mr. A. JONES :—26 Orthoptera ; from Simla, India.

Mr. W. R. S. LADELL :—485 Lepidoptera and 4 early stages, 68 Rhynchota and 5 larvae, and 1,095 Orthoptera ; from Siam.

Dr. W. A. LAMBORN, Medical Entomologist :—20 Culicidae, 3 other Diptera, and 6 Lepidoptera ; from Nyasaland.

Mr. S. LEEFMANS :—11 Coleoptera and 17 Lepidoptera ; from Java.

Dr. C. A. MARELLI :—120 Coleoptera and 138 Lepidoptera ; from the Argentine.

Dr. G. A. K. MARSHALL :—8 Coleoptera, 11 Hymenoptera, 9 Rhynchota, 4 Orthoptera, 2 Planipennia, and 2 Ephemeridae ; from Gallipoli, Anatolia, and Switzerland.

Mr. G. A. MAVROMOUSTAKIS :—45 Orthoptera ; from Cyprus.

Mr. R. N. McCULLOCH :—50 Mites ; from New South Wales, Australia.

Mr. N. C. E. MILLER :—417 Coleoptera, 215 Lepidoptera, and 109 Orthoptera ; from Tanganyika Territory.

Mr. F. J. MITCHELL :—1 *Haematopota*, 1 Ichneumonid, 1 Cicadid, and 31 Orthoptera ; from Kashmir.

Mr. R. W. MUNGOMERY :—6 Coleoptera ; from Queensland, Australia.

MUSÉE DU CONGO BELGE, TERVUEREN :—4 Diptera and 147 Coleoptera ; from the Belgian Congo.

NAIROBI MUSEUM :—510 Hymenoptera ; from Kenya Colony.

Mr. V. A. NIKOLAEV :—84 Orthoptera ; from Turkestan.

Prof. V. V. NIKOLSKY :—24 Culicidae and 11 Orthoptera ; from Russia and Turkestan.

Prof. G. H. F. NUTTALL :—11 *Glossina* and 100 pupa-cases ; from Portuguese East Africa.

Mr. C. PAPACHRYSSOSTOMOU :—10 Psychodidae, 59 other Diptera, 45 Coleoptera, 1,785 Parasitic Hymenoptera, 32 Lepidoptera, and 6 Rhynchota ; from Cyprus.

Mr. W. H. PATTERSON, Government Entomologist :—20 Chalcididae ; from the Gold Coast.

Mr. A. W. PAYNE :—8 Lepidoptera ; from the Fiji Islands.

Mr. H. M. PENDLEBURY :—646 Orthoptera ; from the Federated Malay States.

Mr. A. O. REINKING :—28 Coleoptera and 25 early stages ; from the Dutch East Indies.

Mr. ALI RISA-BEI :—6 Diptera and 10 Hymenoptera ; from Turkey.

Mr. A. H. RITCHIE, Government Entomologist :—59 Diptera, 20 Coleoptera, 3 Mutillidae, 160 Thysanoptera, and 146 Rhynchota and 4 larvae ; from Tanganyika Territory.

Prof. F. SILVESTRI :—12 Lepidoptera ; from China.

SMALL ARMS FACTORY, ENFIELD :—11 Scolytidae ; from India.

Mr. C. B. SYMES :—69 Siphonaptera ; from Kenya Colony.

Mr. P. TCHORBADJIEV :—3 Diptera, 464 Coleoptera, 124 Parasitic Hymenoptera, and 5 Rhynchota ; from Bulgaria.

Mr. H. P. THOMASSET :—4 Culicidae, 15 other Diptera, 39 Coleoptera, 16 Hymenoptera, 567 Lepidoptera, 4 Rhynchota, 21 Orthoptera, 2 Hemerobiidae, 8 Odonata, and 2 Trichoptera ; from Natal.

Mr. R. VEITCH, Chief Entomologist :—18 Diptera and 4 larval skins, 4 Coleoptera, 4 Lepidoptera, and 12 Rhynchota ; from Queensland, Australia.

Mr. S. A. WEBSTER :—18 Coleoptera ; from Yorkshire.

WELLCOME TROPICAL RESEARCH LABORATORIES, KHARTOUM :—544 Coleoptera, 14 Parasitic Hymenoptera, 4 other Hymenoptera, 38 Lepidoptera, and 321 Rhynchota and 40 early stages ; from the Sudan.

Mr. F. X. WILLIAMS :—27 Hymenoptera ; from Hawaii.

Dr. C. L. WITTHYCOMBE :—3 Diptera and 1 Beetle ; from South America.

Mr. G. N. WOLCOTT :—20 Coleoptera ; from Haiti.

ZOOLOGICAL MUSEUM, UKRAINIAN ACADEMY OF SCIENCES, KIEV :—119 Orthoptera ; from Asia.



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